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SITE-SPECIFIC TECHNICAL REPORT FOR BIOSLURPER TESTING AT THE STORAGE TANK 49 SITE, JOHNSTON ATOLL DNA, NORTH PACIFIC

DRAFT

PREPARED FOR:

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
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JOHNSTON ATOLL DNA, NORTH PACIFIC

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SITE-SPECIFIC TECHNICAL REPORT (A003)

for

SHORT-TERM PILOT TEST FOR THE BIOSLURPER INITIATIVE AT THE JOHNSTON ATOLL DEFENSE NUCLEAR AGENCY, NORTH PACIFIC

by

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August 2, 1995

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EXECUTIVE SUMMARY

This report summarizes the field activities conducted at Johnston Atoll Defense Nuclear Agency (DNA), North Pacific, for a short-term field pilot test to compare vacuum-enhanced free-product recovery (bioslurping) to traditional free-product recovery techniques to remove light, nonaqueous-phase liquid (LNAPL) from subsurface soils and aquifers. The field testing at Johnston Atoll is part of the Bioslurper Initiative, which is funded and managed by the U.S. Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division. The AFCEE Bioslurper Initiative is a multisite program designed to evaluate the efficacy of the bioslurping technology for (1) recovery of LNAPL from groundwater and the capillary fringe, and (2) enhancing natural in situ degradation of petroleum contaminants in the vadose zone via bioventing.

The main objective of the Bioslurper Initiative is to develop procedures for evaluating the potential for recovering free-phase LNAPL present at petroleum-contaminated sites. The overall study is designed to evaluate bioslurping and identify site parameters that are reliable predictors of bioslurping performance. To measure LNAPL recovery in a wide variety of in situ conditions, tests are being performed at many sites. The test at Johnston Atoll is one of at least 35 similar field tests to be conducted at various locations throughout the United States and its possessions.

The intent of field testing is to collect data to support determination of the predictability of LNAPL recovery and to evaluate the applicability, cost, and performance of the bioslurping technology for removal of free product and remediation of the contaminated area. The on-site testing is structured to allow direct comparison of the LNAPL recovery achieved by bioslurping with the performance of more conventional LNAPL recovery technologies. The test method included an initial site characterization followed by LNAPL recovery testing. The three LNAPL recovery technologies tested at Johnston Atoll were skimmer pumping, bioslurping, and drawdown pumping.

Site characterization activities were conducted to evaluate site variables that could affect LNAPL recovery efficiency and to determine the bioventing potential of the site. Testing included baildown testing, soil sampling, slug testing, soil gas permeability testing, and in situ respiration testing.

After the site characterization activities, the pilot tests for the skimmer pumping, bioslurping, and drawdown pumping were conducted. The bioslurper system was installed in existing monitoring well PRW #13. The pilot test sequence was as follows: 46 hours in the skimmer configuration, approximately 77 hours in the bioslurper configuration, an additional 22 hours in the skimmer

configuration, and 25.5 hours in the drawdown configuration. Measurements of extracted soil gas composition, LNAPL thickness, and groundwater level were taken throughout the testing. The volumes of LNAPL recovered and groundwater extracted were quantified over time.

Skimmer pumping and drawdown pumping were not as effective at recovering LNAPL as bioslurping at this site. Ratios of groundwater to LNAPL extracted were high in comparison to results from the bioslurper pump test, except during the initial skimmer pump test. During the bioslurper pump test, LNAPL recovery was high initially, with an average rate of 180 gallons/day. LNAPL recovery rates decreased after the first day, with rates ranging from 24 to 40 gallons/day during the remainder of the test. The average LNAPL recovery rate throughout testing was 56 gallons/day.

Soil gas concentrations were measured at monitoring points during the bioslurper pump test to determine whether the vadose zone was being oxygenated. Oxygen concentrations increased significantly at monitoring points JA4-MPA and JA4-MPB at the shallow depths (Table 7). Oxygen concentration at monitoring point JA4-MPA-4.5 did not change during testing, which may be due to an area of low permeability. The bioslurper system did not oxygenate deeper soils at monitoring point JA4-MPC, although the shallow soil was oxygenated. These results correlate with results from the soil gas permeability test.

Implementation of bioslurping at the Johnston Atoll test site probably would facilitate enhanced recovery of LNAPL from the water table and simultaneous in situ biodegradation of hydrocarbons in the vadose zone via bioventing. The feasibility of implementing bioslurping will depend on long-term water discharge requirements. An economically viable method of treating and/or disposing of the extracted water must be found before a long-term test can be undertaken.

DRAFT SITE-SPECIFIC TECHNICAL REPORT (A003)

for

SHORT-TERM PILOT TEST FOR THE BIOSLURPER INITIATIVE AT THE JOHNSTON ATOLL DEFENSE NUCLEAR AGENCY, NORTH PACIFIC

August 2, 1995

1.0 INTRODUCTION

This report describes activities performed and data collected during a field test at Johnston Atoll Defense Nuclear Agency (DNA), North Pacific, to compare vacuum-enhanced free-product recovery (bioslurping) to traditional free-product recovery technologies for removal of light, nonaqueous-phase liquid (LNAPL) from subsurface soils and aquifers. The field testing at Johnston Atoll is part of the Bioslurper Initiative, which is funded and managed by the U.S. Air Force Center for Environmental Excellence (AFCEE) Technology Transfer Division. The AFCEE Bioslurper Initiative is a multisite program designed to evaluate the efficacy of the bioslurping technology for (1) recovery of LNAPL from groundwater and the capillary fringe and (2) enhancing natural in situ degradation of petroleum contaminants in the vadose zone via bioventing.

1.1 Objectives

The main objective of the Bioslurper Initiative is to develop procedures for evaluating the potential for recovering free-phase LNAPL present at petroleum-contaminated sites. The overall study is designed to evaluate bioslurping and identify site parameters that are reliable predictors of bioslurping performance. To measure LNAPL recovery in a wide variety of in situ conditions, tests are being performed at many sites. The test at Johnston Atoll is one of at least 35 similar field test to be conducted at various locations throughout the United States and its possessions. Aspects of the testing program that apply to all sites are described in the *Test Plan and Technical Protocol for Bioslurping* (Battelle, 1995). Test provisions specific to activities at Johnston Atoll were described in the Site-Specific Test Plan provided in Appendix A.

The intent of field testing is to collect data to support determination of the predictability of LNAPL recovery and to evaluate the applicability, cost, and performance of the bioslurping

technology for removal of free product and remediation of the contaminated area. The on-site testing is structured to allow direct comparison of the LNAPL recovery achieved by bioslurping with the performance of more conventional LNAPL recovery technologies. The test method included an initial site characterization followed by LNAPL recovery testing. The three LNAPL recovery technologies tested at Johnston Atoll were skimmer pumping, bioslurping, and drawdown pumping. The specific test objectives, methods, and results for the Johnston Atoll test program are discussed in the following sections.

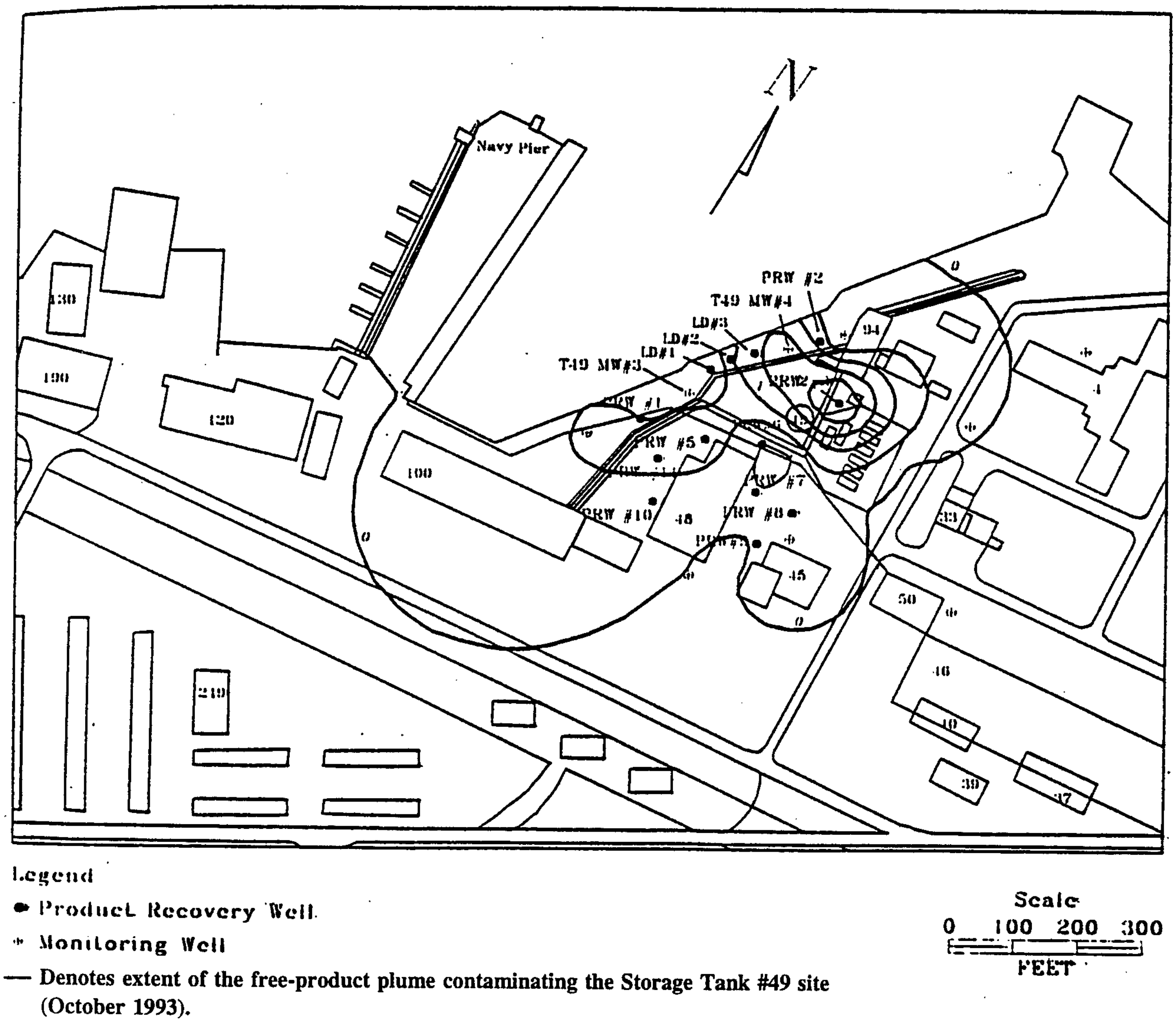
1.2 Testing Approach

Site characterization activities were conducted to evaluate site variables that could affect LNAPL recovery efficiency and to determine the bioventing potential of the site. Testing included baildown testing to evaluate the mobility of LNAPL, soil sampling to determine physical/chemical site characteristics, slug testing to evaluate the hydrogeologic conditions near the test well, soil gas permeability testing to determine the radius of influence, and in situ respiration testing to evaluate site microbial activity.

Following the site characterization activities, the pilot tests for skimmer pumping, bioslurping, and drawdown pumping were conducted. The LNAPL recovery testing was conducted in the following sequence: 46 hours in the skimmer configuration, approximately 77 hours in the bioslurper configuration, an additional 22 hours in the skimmer configuration, and 25.5 hours in the drawdown configuration. Measurements of extracted soil gas composition, LNAPL thickness, and groundwater level were taken throughout the testing. The volume of LNAPL recovered and groundwater extracted were quantified over time.

2.0 SITE DESCRIPTION

Figure 1 illustrates the location at Johnston Atoll of the Storage Tank 49 Site used for pilot testing. The locations of groundwater monitoring wells and soil gas monitoring points at the Storage Tank 49 Site are illustrated in Figure 2. The soils on Johnston Atoll typically consist of compacted crushed coral. Surface vegetation is sparse, consisting of grasses within the bermed area of the



— Denotes extent of the free-product plume contaminating the Storage Tank #49 site (October 1993).

Figure 1. Schematic Diagram of the Storage Tank 49 Site, Johnston Atoll DNA, Showing Locations of Free Product Recovery and Monitoring Wells

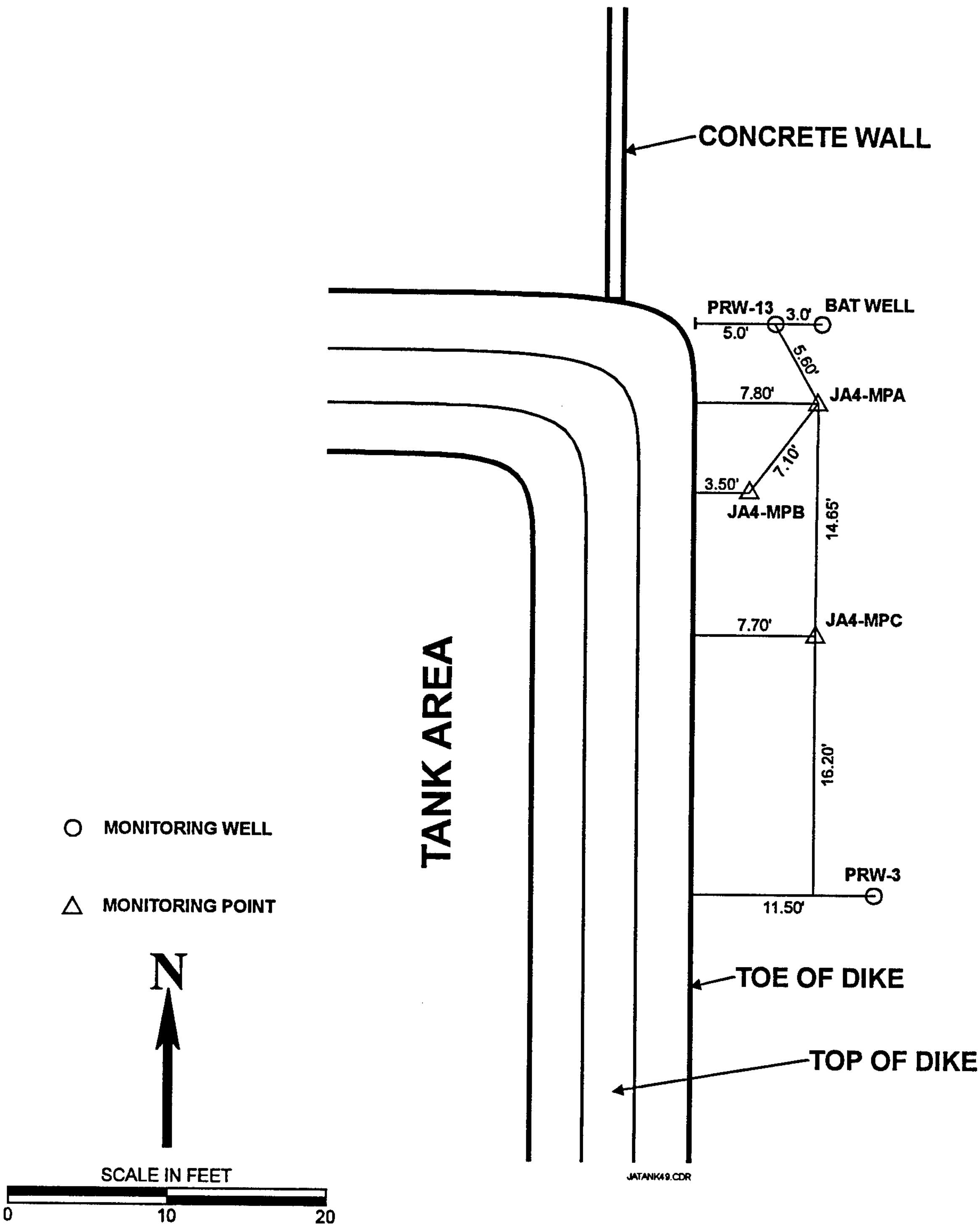


Figure 2. Location of Groundwater Monitoring Wells and Soil Gas Monitoring Points at the Storage Tank 49 Site, Johnston Atoll

Storage Tank 49 Site. The Storage Tank 49 Site is located adjacent to the lagoon. The shoreline is protected by a vertical concrete seawall, extending 15 ft below ground surface.

Currently, the area is operational, with all petroleum product storage tanks still in use. No. 2 fuel oil was stored in both Tank 49 and the day-use tank until November 1991, when the island's fuel oil uses were converted to JP-5 jet fuel.

Leaks and spills within the Storage Tank 49 Site have been poorly documented, but it is believed that fuel may have leaked from the tank from the 1960s to 1987. In 1987, a leak occurred from the base of Tank 49. Site staff who witnessed the resultant contamination estimated that the volume of fuel spilled ranged from 5,000 to 20,000 gallons. Release of the product to the lagoon through cracks in the seawall has been persistent. A fuel sheen is noticeable at low tides on the surface of the lagoon.

3.0 BIOSLURPER SHORT-TERM PILOT TEST METHODS

This section documents the initial conditions at the test site and describes the test equipment and methods used for the short-term pilot test at Johnston Atoll.

3.1 Initial LNAPL/Groundwater Measurements and Baildown Testing

Monitoring wells PRW #3, PRW #11, and PRW #13 were evaluated for use in the bioslurper pilot testing. Initial depths to LNAPL and to groundwater were measured using an oil/water interface probe (ORS Model #1068013). LNAPL was removed from the well with a Teflon™ bailer until the LNAPL thickness could no longer be reduced. The rate of increase in the thickness of the floating LNAPL layer was monitored for approximately 19 hours using the oil/water interface probe.

3.2 Well Construction Details

Existing monitoring well PRW #13 was selected for use in the bioslurper pilot testing. The well is constructed of 2-inch-diameter, schedule 40 polyvinyl chloride (PVC) with a total depth of 13 ft and 10 ft of screen. A schematic diagram illustrating the well construction details is provided in Figure 3.

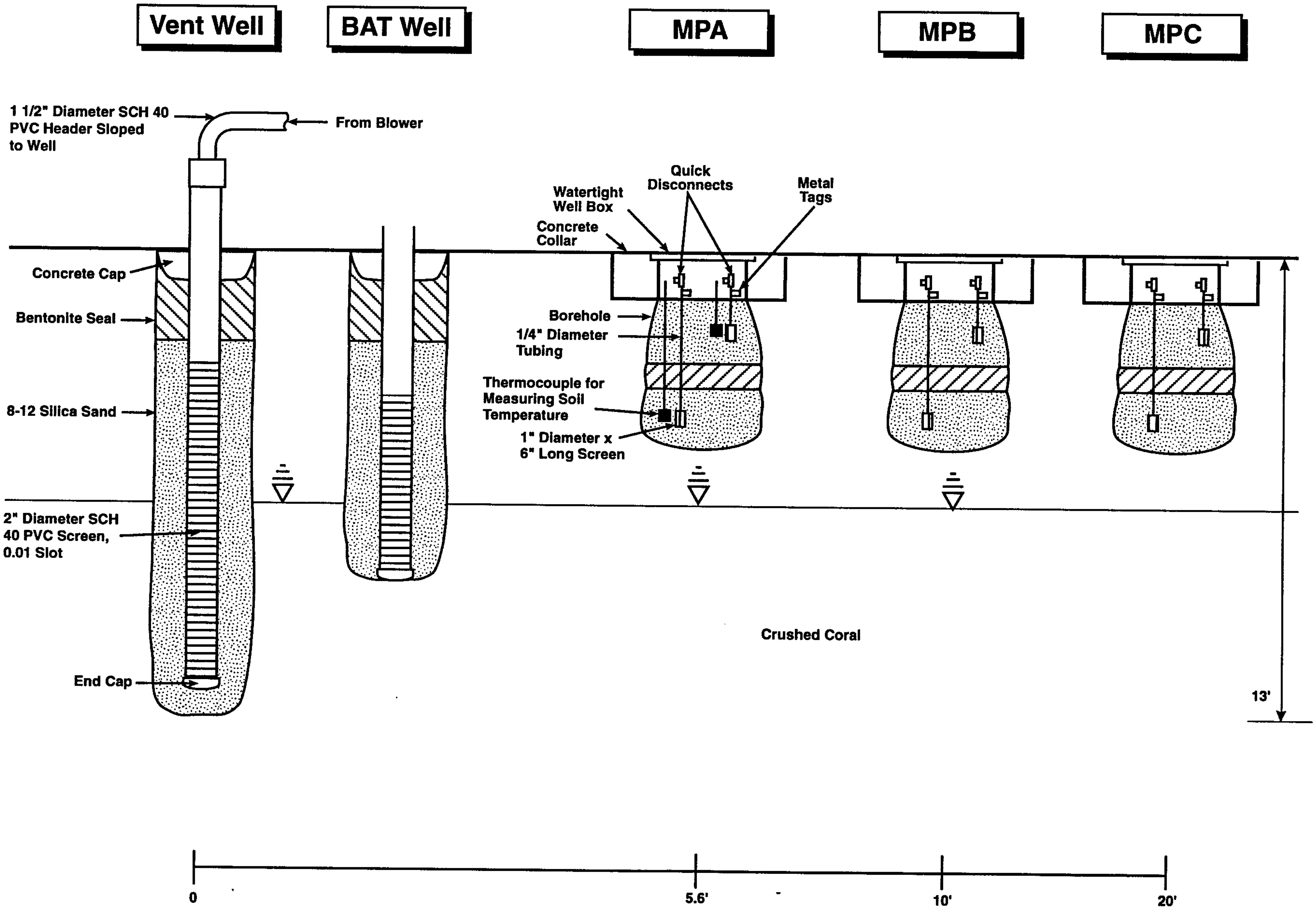


Figure 3. Schematic Diagram Illustrating Site Lithology and Construction Details of the Bioslurper Well and Soil Gas Monitoring Points at the Storage Tank 49 Site, Johnston Atoll

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An additional well was installed near monitoring well PRW #13 to measure changes in depths to fuel and groundwater during bioslurping. The well was labeled BAT WELL and was constructed of 2-inch-diameter, schedule 40 PVC with a total depth of 9.33 ft and 5 ft of slotted screen. A schematic diagram illustrating the well construction details is provided in Figure 3.

3.3 Soil Gas Monitoring Point and Thermocouple Installation

On June 3, 1995, three monitoring points were installed in the area of monitoring well PRW #13 and were labeled JA4-MPA, JA4-MPB, and JA4-MPC. The locations and construction details of the monitoring points are illustrated in Figures 2 and 3, respectively.

The monitoring points consisted of sets of ¼-inch tubing, with 1-inch-diameter, 6-inch-long screened areas. The screened lengths were positioned at the appropriate depths, and the annular space corresponding to the screened length was filled with silica sand. The interval between the screened lengths was filled with bentonite clay chips, as was the space from the top of the shallowest screened length to the ground surface. After placement, the bentonite clay was hydrated with water to expand the chips and provide a seal.

All monitoring points were installed in a 6-inch-diameter borehole to a depth of 5.0 ft. Screened lengths were placed at three depths: 2.0 to 2.5 ft and 4.5 to 5.0 ft. Two type K thermocouples were installed in monitoring point JA4-MPA at depths of 2.0 and 4.5 ft.

After installation of the monitoring points, initial soil gas measurements were taken with a GasTechtor portable O_2/CO_2 meter and a GasTech Trace-Techtor portable hydrocarbon meter. In general, oxygen limitation was observed at all monitoring point depths, with oxygen concentrations ranging from 0% to 16.0% (Table 1).

3.4 Soil Sampling and Analyses

Five soil samples were collected during the installation of monitoring well BAT WELL. The soil samples were collected in brass sleeves driven down the center of the hollow-stem auger used to drill the monitoring well. The samples were labeled as follows: JA4-4.5-6.0, JA4-5.0-5.5, JA4-5.5-6.0, JA4-6.0-7.5, and JA4-7.0-7.5. The samples were placed in insulated coolers, chain-of-custody records and shipping papers were completed, and the samples were sent to Pace, Inc., in Fountain Valley, California by overnight express. Samples JA4-5.0-5.5, JA4-5.5-6.0, and JA4-7.0-7.5 were

Table 1. Initial Soil Gas Compositions at the Storage Tank 49 Site, Johnston Atoll

Monitoring Point	Depth (ft)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppmv)
JA4-MPA	2.0	1.2	10.3	1,200
	4.5	0	12.1	1,400
JA4-MPB	2.0	16.0	4.0	96
	4.5	13.0	6.0	480
JA4-MPC	2.0	4.8	9.2	1,000
	4.5	3.7	10.5	1,400

analyzed for benzene, toluene, ethylbenzene, and total xylenes (BTEX) and total petroleum hydrocarbons (TPH). Samples JA4-4.5-6.0 and JA4-6.0-7.5 were analyzed for bulk density, moisture content, particle size, and porosity. Laboratory analytical reports for all five samples are provided in Appendix B.

3.5 LNAPL Recovery Testing

Descriptions of the LNAPL recovery testing is discussed in the following sections. During the pump tests, the depth to groundwater was measured in sealed monitoring well PRW #3 and depths to groundwater and fuel were measured in sealed monitoring well BAT WELL. These measurements were collected to monitor tidal fluctuations during the testing. These results are provided in Appendix C.

3.5.1 System Setup

The bioslurping pilot test system is a trailer-mounted mobile unit. The vacuum pump (Atlantic Fluidics Model A100, 3-hp liquid ring pump), oil/water separator, and required support equipment are carried to the test location on a trailer. The trailer was located near monitoring well PRW #13, the well cap was removed, a coupling and tee were attached to the top of the well, and the slurper tube was lowered into the well. The slurper tube was attached to the vacuum pump.

Different configurations of the tee and the placement depth of the slurper tube allow for simulation of skimmer pumping, operation in the bioslurping configuration, or simulation of drawdown pumping as described in Sections 3.5.2, 3.5.3, and 3.5.5, respectively.

A brief system startup test was performed prior to LNAPL recovery testing to ensure that all system components were working properly. The system checklist is provided in Appendix D. All site data and field testing information were recorded in a field notebook and then transcribed onto pilot test data sheets provided in Appendix E.

3.5.2 Initial Skimmer Pump Test

Prior to test initiation, depths to LNAPL and groundwater were measured. The slurper tube was then set at the LNAPL/groundwater interface with the wellhead open to the atmosphere via a PVC connecting tee (Figure 4). The liquid ring pump and oil/water separator were primed with known amounts of groundwater to ensure that any LNAPL or groundwater entering the system could be quantified. The flow totalizers for the LNAPL and aqueous effluent were zeroed, and the liquid ring pump was started on June 5, 1995, to begin the skimmer pump test. The test was operated continuously for 46 hours. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the skimmer pump test. Test data sheets are provided in Appendix E.

3.5.3 Bioslurper Pump Test

Upon completion of the skimmer pump test, preparations were made to begin the bioslurper pump test. Prior to test initiation, depths to LNAPL and groundwater were measured. The slurper tube was then set at the LNAPL/groundwater interface, as in the skimmer pump test. However, in contrast to the skimmer pump test, the PVC connecting tee was removed, sealing the wellhead and allowing the pump to establish a vacuum in the well (Figure 5). A pressure gauge was installed at the wellhead to measure the vacuum inside the extraction well. The liquid ring pump and oil/water separator were primed with known amounts of groundwater to ensure that any LNAPL or groundwater entering the system could be quantified. The flow totalizers for the LNAPL and aqueous effluent were zeroed, and the liquid ring pump was started on June 8, 1995, to begin the bioslurper pump test. The test was initiated approximately 16.5 hours after the skimmer pump test and was

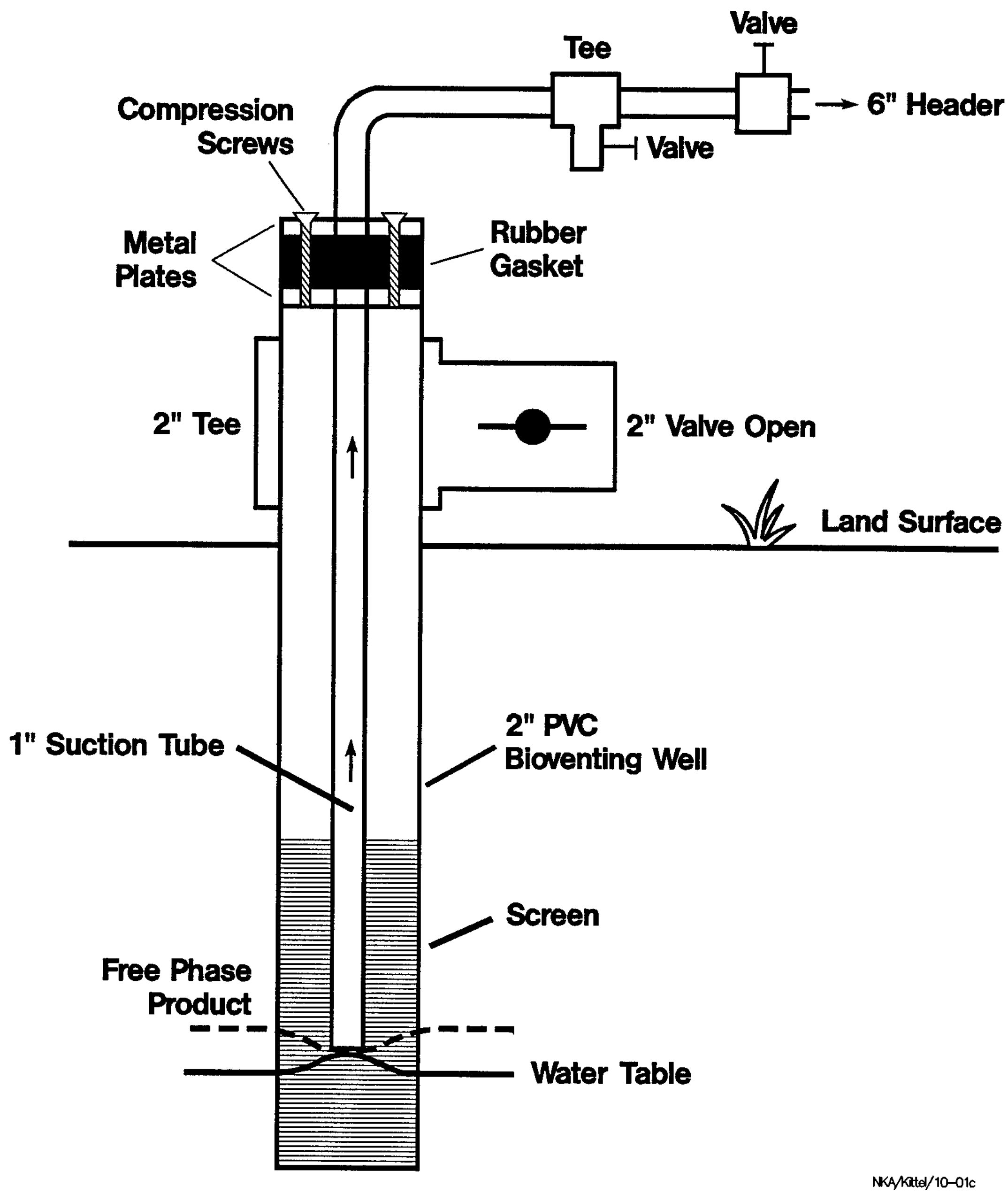

Figure 4. Slurper Tube Placement and Valve Position for the Skimmer Pump Test

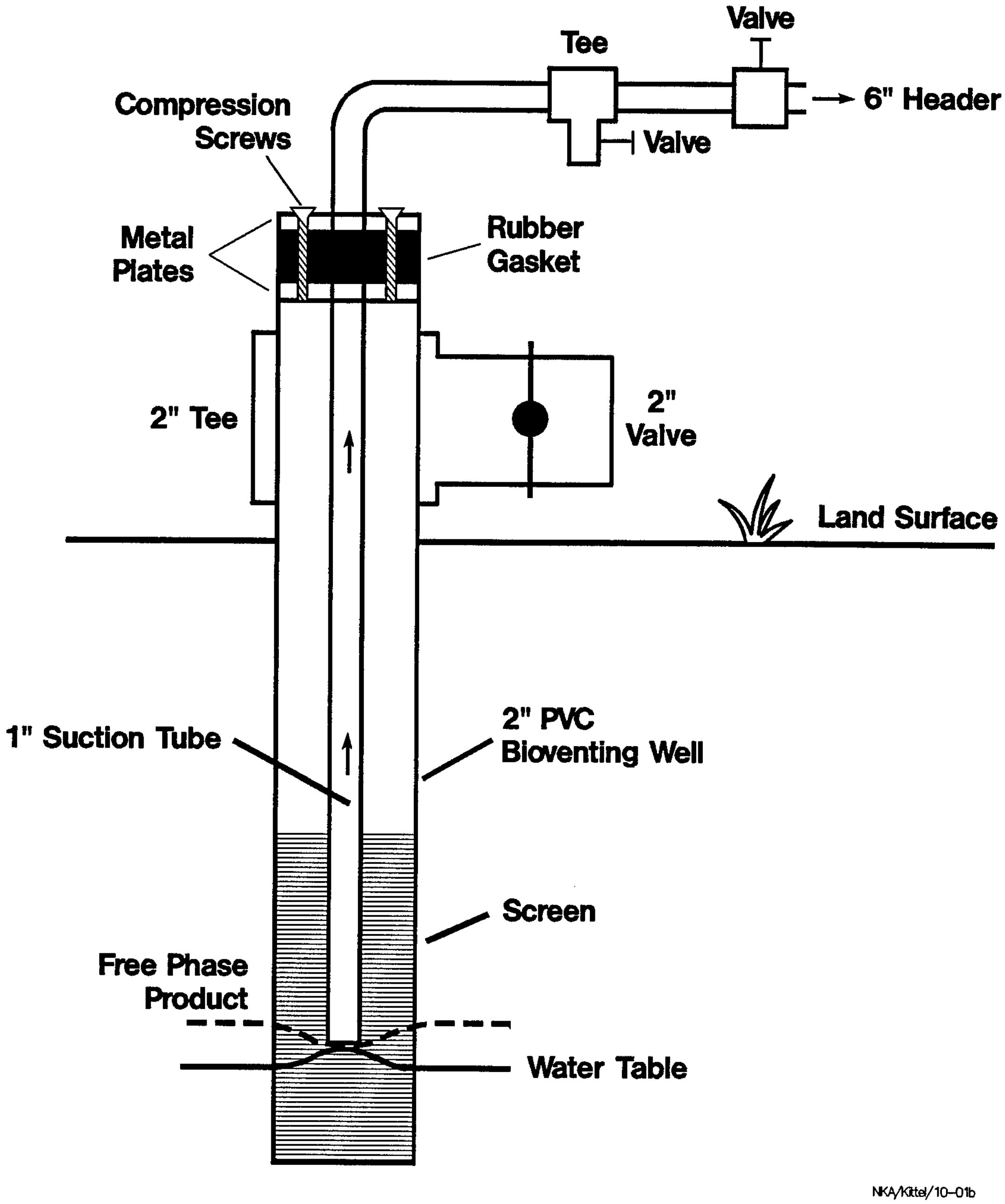

Figure 5. Slurper Tube Placement and Valve Position for the Bioslurper Pump Test

operated continuously for approximately 77 hours. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the bioslurper pump test. Test data sheets are provided in Appendix E.

3.5.4 Second Skimmer Pump Test

Upon completion of the bioslurper pump test, preparations were made to begin the second skimmer pump test. Prior to test initiation, depths to LNAPL and groundwater were measured. The valve and slurper tube configuration were identical to that for the initial skimmer pump test. The liquid ring pump and oil/water separator were primed with known amounts of groundwater to ensure that any LNAPL or groundwater entering the system could be quantified. The flow totalizers for the LNAPL and aqueous effluent were zeroed, and the liquid ring pump was started on June 12, 1995, to begin the second skimmer pump test. The test was initiated approximately 15 hours after the bioslurper pump test and was operated continuously for 22 hours. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the bioslurper pump test. Test data sheets are provided in Appendix E.

3.5.5 Drawdown Pump Test

Upon completion of the second skimmer pump test, preparations were made to begin the drawdown pump test. Prior to test initiation, depths to LNAPL and groundwater were measured. The slurper tube was then set so that the tip was 15 inches below the oil/water interface with the PVC connecting tee open to the atmosphere (Figure 6). The liquid ring pump and oil/water separator were primed with known amounts of groundwater to ensure that any LNAPL or groundwater entering the system could be quantified. The flow totalizers for the LNAPL and aqueous effluent were zeroed, and the liquid ring pump was started on June 13, 1995, to begin the drawdown pump test. The test was initiated approximately 0.5 hour after the second skimmer pump test and was operated continuously for 25.5 hours. The LNAPL and groundwater extraction rates were monitored throughout the test, as were all other relevant data for the drawdown pump test. Test data sheets are provided in Appendix E.

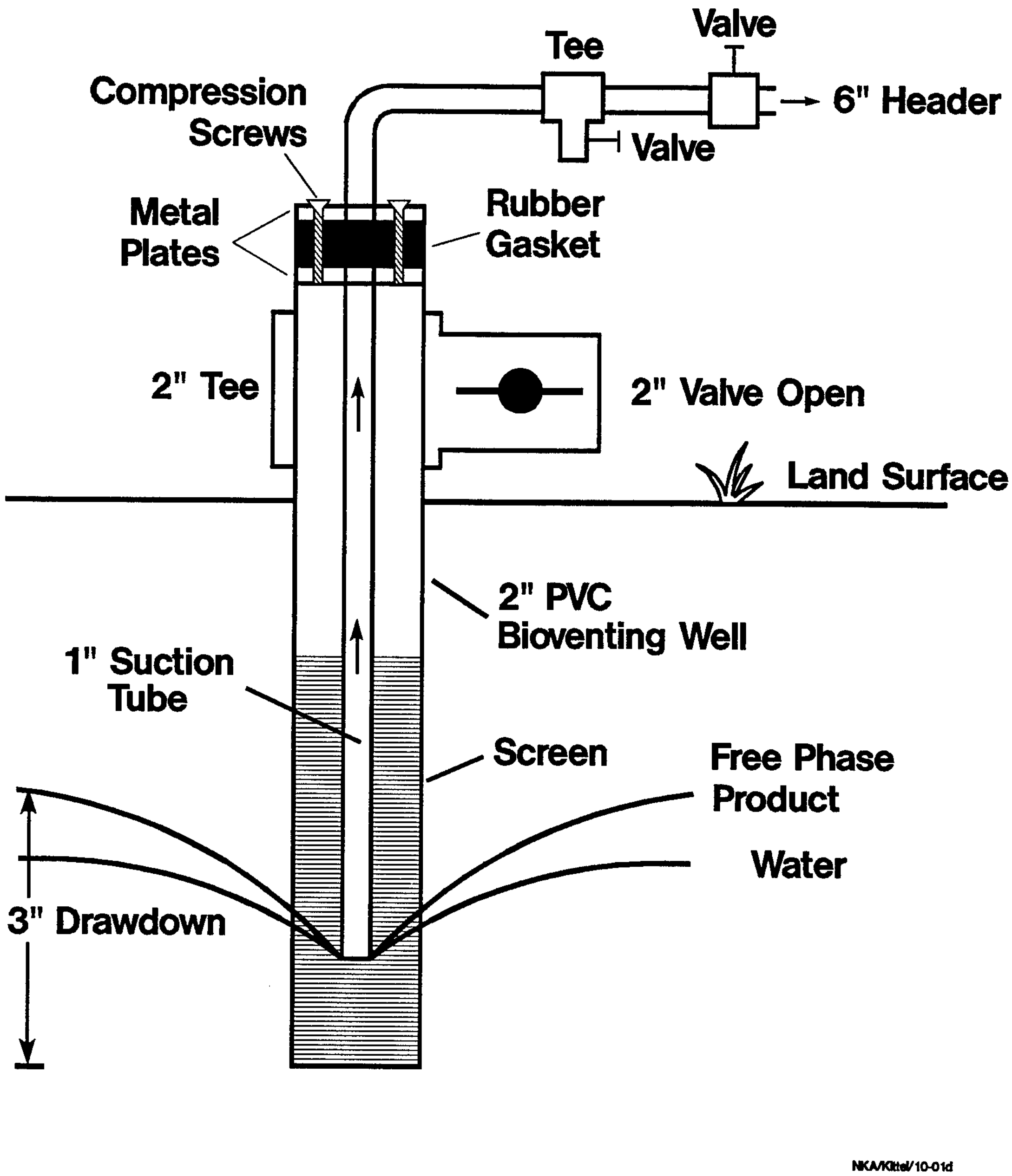

Figure 6. Slurper Tube Placement and Valve Position for the Drawdown Pump Test

3.5.6 Off-Gas Sampling and Analyses

Soil gas samples were collected from the bioslurper off-gas during the bioslurper pump test. Samples were collected in Summa™ canisters approximately 6 and 75 hours after test initiation and were labeled JA4-STK-1 and JA4-STK-2, respectively. The samples were sent under chain of custody to Air Toxics, Ltd., in Rancho Cordova, California, for analyses of BTEX and TPH.

3.5.7 Extracted LNAPL and Groundwater Sampling and Analyses

Two groundwater samples were collected from the oil/water separator during the bioslurper pump test. Samples were collected at test initiation and completion and were labeled JA4-EFF-1 and JA4-EFF-2, respectively. Samples were collected in 40-mL septa vials containing HCl preservative. Samples were checked to ensure no headspace was present and were then shipped on ice and sent under chain of custody to the Environmental Laboratory of the Pacific, Honolulu, Hawaii, for analyses of BTEX and TPH.

A sample of LNAPL was collected from the oil/water separator for analyses of BTEX and was labeled JA4-Fuel. The sample was shipped on ice to Pace, Inc., Fountain Valley, California by overnight express.

3.6 Soil Gas Permeability Testing

The soil gas permeability test data were collected during the bioslurper pump test. Before a vacuum was established in the extraction well, the initial soil gas pressures at the three installed monitoring points were recorded. The start of the bioslurper pump test created a steep pressure drop in the extraction well which was the starting point for the soil gas permeability testing. Soil gas pressures were measured at each of the three monitoring points at all depths to track the rate of outward propagation of the pressure drop in the extraction well. Soil gas pressure data were collected frequently during the first 20 minutes of the test. The soil gas pressures were recorded throughout the bioslurper pump test to determine the bioventing radius of influence. Test data are provided in Appendix F.

3.7 In Situ Respiration Testing

Air containing approximately 2% helium was injected into three monitoring points for approximately 24 hours beginning on June 12, 1995. The setup for the in situ respiration test is described in the *Test Plan and Technical Protocol for Bioventing* (Hinchee et al., 1992). A ½-hp diaphragm pump was used for air and helium injection. Air and helium were injected through the following monitoring points at the depths indicated: JA4-MPA-4.5′, JA4-MPC-2.0′, and JA4-MPC-4.5′. After the air/helium injection was terminated, soil gas concentrations of oxygen, carbon dioxide, TPH, and helium were monitored periodically. The respiration test was terminated on June 15, 1995. Oxygen utilization and biodegradation rates were calculated as described in Hinchee et al. (1992). Raw data for these tests are presented in Appendix G.

Helium concentrations were measured during the in situ respiration test to quantify helium leakage to or from the surface around the monitoring points. Helium loss over time is attributable to either diffusion through the soil or leakage. A rapid drop in helium concentration usually indicates leakage. A gradual loss of helium along with a first-order curve generally indicates diffusion. As a rough estimate, the diffusion of gas molecules is inversely proportional to the square root of the molecular weight of the gas. Based on molecular weights of 4 for helium and 32 for oxygen, helium diffuses approximately 2.8 times faster than oxygen, or the diffusion of oxygen is 0.35 times the rate of helium diffusion. As a general rule, we have found that if helium concentrations at test completion are at least 50 to 60% of the initial levels, measured oxygen uptake rates are representative. Greater helium loss indicates a problem, and oxygen utilization rates are not considered representative.

4.0 RESULTS

This section documents the results of the site characterization, the comparative LNAPL recovery pump test, and other supporting tests conducted at Johnston Atoll.

4.1 Baildown Test Results

Results from baildown tests in monitoring wells PRW #11 and PRW #13 are presented in Table 2. A baildown test was not performed on monitoring well PRW #3 due to an absence of free

Table 2. Results of Baildown Testing in Monitoring Wells PRW #11 and PRW #13

Monitoring Well	Date-Time	Depth to LNAPL (ft)	Depth to Groundwater (ft)	LNAPL Thickness (ft)
PRW #11	Initial Reading 6/2/95-1453	7.34	7.78	0.44
	6/2/95-1500	7.36	7.60	0.24
	6/2/95-1515	7.30	7.89	0.59
	6/2/95-1542	7.23	7.92	0.69
	6/3/95-0930	6.73	7.30	0.57
PRW #13	Initial Reading 6/2/95-1400	6.41	8.01	1.60
	6/2/95-1426	6.60	7.02	0.42
	6/2/95-1436	6.485	7.64	1.155
	6/2/95-1440	6.47	7.25	0.78
	6/2/95-1550	6.43	7.935	1.505
	6/3/95-0925[1]	6.39	6.64	0.25

[1] Measurement was taken at high tide.

product. A total volume of 0.32 L (0.085 gallon) and 3.5 L (0.92 gallon) of LNAPL was removed by hand bailing from monitoring wells PRW #11 and PRW #13, respectively. The LNAPL thickness recovered to approximately initial levels by the end of the test in both wells (Table 2). Based on the amount of free product recovered and free product thickness, monitoring well PRW #13 was selected for the bioslurper field testing.

4.2 Soil Sample Analyses

Table 3 shows the BTEX and TPH concentrations measured in soil samples collected from the Storage Tank 49 Site. Concentrations of TPH, benzene, and toluene were below detection limits. Concentrations of ethylbenzene and xylenes ranged from 0.24 to 0.72 mg/kg.

Table 3. **BTEX and TPH Concentrations in Soil Samples from the Storage Tank 49 Site, Johnston Atoll**

Parameter	Concentration (mg/kg)		
	JA4-5.0-5.5	JA4-5.5-6.0	JA4-7.0-7.5
TPH as jet fuel	<83	<330	<330
Benzene	<0.050	<0.050	<0.050
Toluene	<0.050	<0.050	<0.050
Ethylbenzene	0.24	0.72	0.49
Xylenes	0.30	0.51	0.38

A sieve analysis also was performed on soil samples to determine the grain-size distribution. The analysis indicated that the site soil consisted of approximately 22% gravel, 59% sand, and 19% silt and clay. The results of the physical characterization of the soils are presented in Table 4.

4.3 LNAPL Pump Test Results

4.3.1 Initial Skimmer Pump Test Results

The LNAPL thickness prior to the initial skimmer pump test was 0.84 ft (Table 5). A total of 56.8 gallons of LNAPL were recovered during this test, with average recovery rates of 29.8 gallons/day (Table 6). A total of 268.2 gallons of groundwater were extracted with average extraction rates of 141 gallons/day (Table 6). Results of LNAPL recovery versus time are shown in Figure 7.

4.3.2 Bioslurper Pump Test Results

LNAPL recovery rates increased significantly during the bioslurper pump test (Figure 7). The increase in recovery rate indicates that LNAPL was mobilized to the extraction well under vacuum-enhanced conditions. A total of 180.7 gallons of LNAPL and 4,390 gallons of groundwater

Table 4. Physical Characterization of Soil from the Storage Tank 49 Site, Johnston Atoll

Parameter		Sample	
		JA4-4.5-6.0	JA4-6.0-7.5
Moisture Content (%)		17.1	17.0
Porosity (%)		49.0	48.4
Specific Gravity (g/cm^3)		2.67	2.67
U.S. Standard Sieve Size: Cumulative % Passing	1½ inch	100	100
	¾ inch	100	97
	⅜ inch	100	83
	No. 4	92	75
	No. 10	81	65
	No. 20	70	53
	No. 40	58	37
	No. 60	41	28
	No. 100	31	23
	No. 200	24	18

Table 5. Depths to Groundwater and LNAPL Prior to Each Pump Test

Test	Test Start Date	Depth to LNAPL (ft)	Depth to Groundwater (ft)	LNAPL Thickness (ft)
Initial Skimmer Pump Test	6/5/95	6.97	7.81	0.84
Bioslurper Pump Test	6/8/95	7.02	8.68	1.66
Second Skimmer Pump Test	6/12/95	7.065	7.42	0.355
Drawdown Pump Test	6/13/95	NM	6.94	NM

NM = Not measured.

Table 6. Pump Test Results at the Storage Tank 49 Site, Johnston Atoll

Recovery Rate (gal/day)	Initial Skimmer Pump Test		Bioslurper Pump Test		Second Skimmer Pump Test		Drawdown Pump Test	
	LNAPL	Groundwater	LNAPL	Groundwater	LNAPL	Groundwater	LNAPL	Groundwater
Day 1	13.8	83.1	180	1,450	3.6	432	9.0	1,470
Day 2	46.6	201	35	1,330	NA	NA	NA	NA
Day 3	NA	NA	24	1,370	NA	NA	NA	NA
Day 4	NA	NA	40	1,380	NA	NA	NA	NA
Average	29.8	141	56	1,370	3.6	432	9.0	1,470
Total Recovered (gal)	56.8	268.2	180.7	4,390	3.3	396	9.55	1,565

NA = Not applicable.

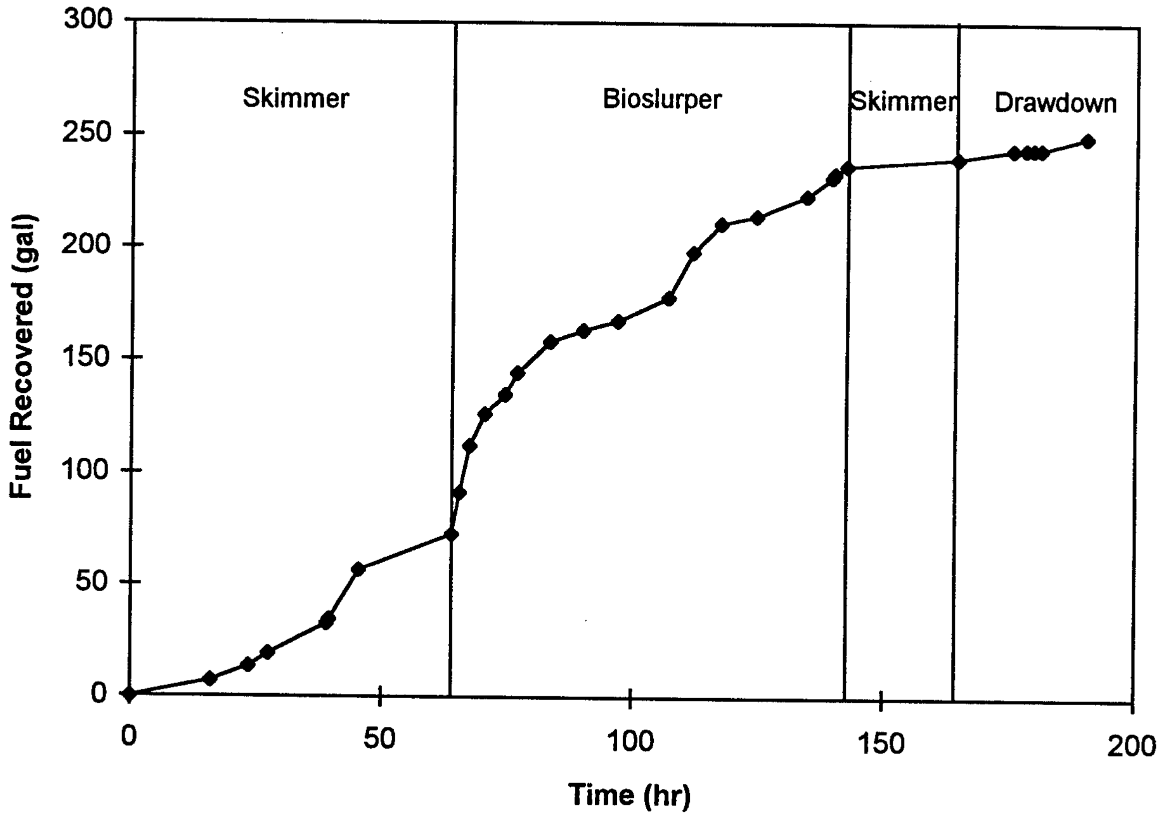

Figure 7. LNAPL Recovery Versus Time During Each Pump Test

were extracted during the bioslurper pump test, with daily average recovery rates of 56 gallons/day for LNAPL and 1,370 gallons/day for groundwater (Table 6). The LNAPL recovery rate versus time is shown in Figure 8. The vacuum-exerted wellhead pressure on monitoring well PRW #13 was kept relatively constant throughout the bioslurper pump test at approximately 15 inches of mercury.

Soil gas concentrations were measured at monitoring points during the bioslurper pump test to determine whether the vadose zone was being oxygenated. Oxygen concentrations increased significantly at monitoring points JA4-MPA and JA4-MPB at the shallow depths (Table 7). Oxygen concentration at monitoring point JA4-MPA-4.5 did not change during testing, which may be due to an area of low permeability. The bioslurper system did not oxygenate deeper soils at monitoring point JA4-MPC, although the shallow soil was oxygenated. These results correlate with results from the soil gas permeability test (Section 4.5.1).

Table 7. Oxygen Concentrations During the Bioslurper Pump Test at the Storage Tank 49 Site, Johnston Atoll

Monitoring Point	Oxygen Concentrations (%) Versus Time (minutes)							
	0	90	742	1,370	1,680	2,700	3,510	4,320
JA4-MPA-2.0′	6	14.8	17.5	19.0	17.9	20.0	20.5	13.5
JA4-MPA-4.5′	0	0	0.2	0.5	0.3	0.3	0.3	0
JA4-MPB-2.0′	13.1	20.0	20.9	20.8	20.9	20.9	20.8	20.0
JA4-MPB-4.5′	0	3.0	8.2	11.9	14.0	15.7	16.3	16.5
JA4-MPC-2.0′	0	3.8	7.5	8.0	8.5	8.7	9.0	8.5
JA4-MPC-4.5′	0	0	0	0	0	0	0	0

4.3.3 Second Skimmer Pump Test

Totals of 3.3 gallons of LNAPL and 396 gallons of groundwater were recovered during the second skimmer pump test, with daily average recovery rates of 3.6 gallons/day for LNAPL and 432 gallons/day for groundwater (Table 6). These results demonstrate that operation of the bioslurper

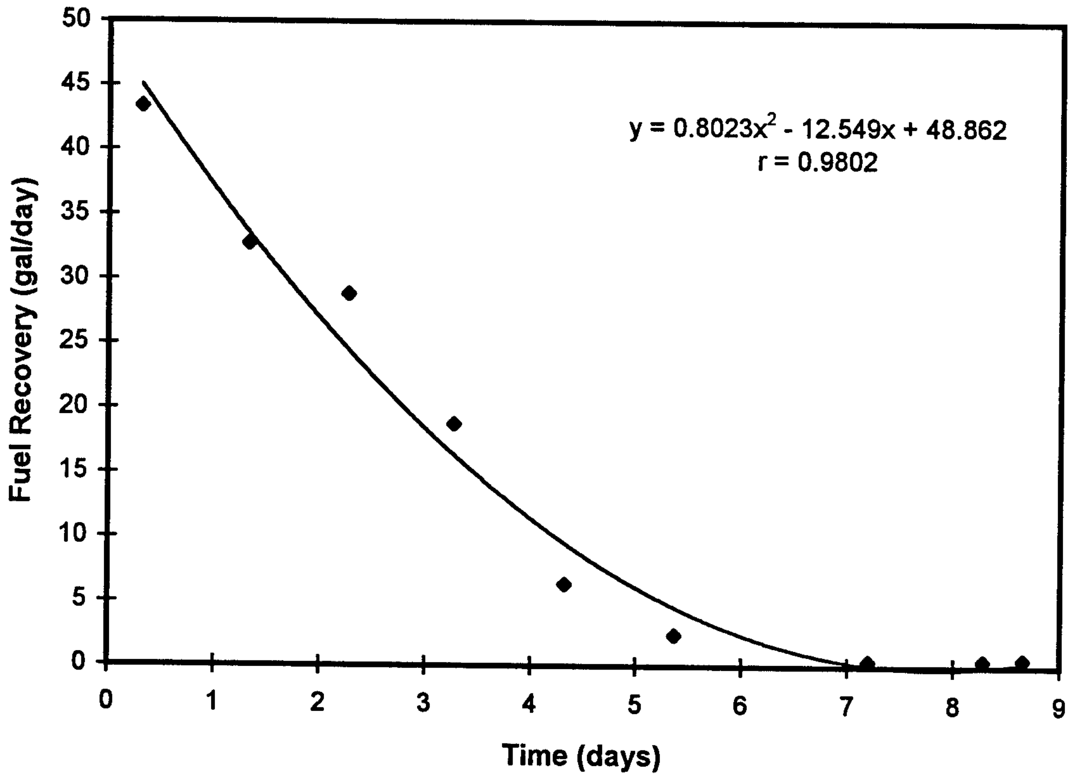

Figure 8. LNAPL Recovery Rate Versus Time During the Bioslurper Pump Test

system in the skimmer mode was not as effective a means of free-product recovery as the bioslurper system at this site.

4.3.4 Drawdown Pump Test

Results from the drawdown pump test were similar to those from the skimmer pump tests (Figure 7). A high ratio of LNAPL to groundwater was extracted, with totals of 9.55 gallons of LNAPL and 1,565 gallons of groundwater extracted (Table 6). These results demonstrate that operation of the bioslurper system in the drawdown mode was not as effective a means of free-product recovery as the bioslurper system at this site.

4.4 Extracted Groundwater, LNAPL, and Off-Gas Analyses

During the bioslurper pump test, groundwater samples from the oil/water separator were collected. TPH and BTEX concentrations were below detection limits in all samples (Table 8).

Off-gas samples from the bioslurper system also were collected during the bioslurper pump test. The results from the off-gas analyses are presented in Table 9. Contaminant concentrations increased slightly during the course of the bioslurper pump test. Given a vapor discharge rate of 10 scfm and using an average concentration of 975 ppmv TPH, approximately 5.7 lb/day of TPH was emitted to the air during the bioslurper pump test.

The composition of LNAPL is shown in Tables 10 and 11 in terms of BTEX concentrations and distribution of C-range compounds, respectively. The distribution of C-range compounds is shown graphically in Figure 9.

4.5 Bioventing Analyses

4.5.1 Soil Gas Permeability and Radius of Influence

The radius of influence is calculated by plotting the log of the pressure change at a specific monitoring point versus the distance from the extraction well. The radius of influence is then defined as the distance from the extraction well where 0.1 inch of H_2O can be measured. Based on this definition, the radius of influence at this site is approximately 15 ft (Figure 10).

Table 8. **BTEX and TPH Concentrations in Extracted Groundwater During the Bioslurper Pump Test at the Storage Tank 49 Site, Johnston Atoll**

Parameter	Concentration (mg/L)	
	JA4-EFF-1	JA4-EFF-2
TPH	<1.0	<1.0
Benzene	<0.0010	<0.0010
Toluene	<0.0010	<0.0010
Ethylbenzene	<0.0010	<0.0010
Xylenes	<0.0020	<0.0020

Table 9. **BTEX and TPH Concentrations in Off-Gas During the Bioslurper Pump Test at the Storage Tank 49 Site, Johnston Atoll**

Parameter	Concentration (ppmv)	
	JA4-STK-1	JA4-STK-2
TPH as jet fuel	850	1,100
Benzene	0.54	0.65
Toluene	2.9	0.36
Ethylbenzene	1.5	2.2
Xylenes	1.3	2.3

Table 10. C-Range Compounds in LNAPL from the Storage Tank 49 Site, Johnston Atoll

Compound	Concentrations (mg/kg)
Benzene	<0.10
Toluene	0.10
Ethylbenzene	1.8
Total Xylenes	0.64

Table 11. C-Range Compounds in LNAPL from the Storage Tank 49 Site, Johnston Atoll

C-Range Compounds	Percentage of Total
<C10	2.80
C10 - C12	11.53
C12 - C14	19.89
C14 - C16	32.58
C16 - C18	24.41
C18 - C20	5.43
C20 - C22	2.37
C22 - C24	0.74
C24 - C26	0.05
C26 - C28	0.22
>C28	0.06

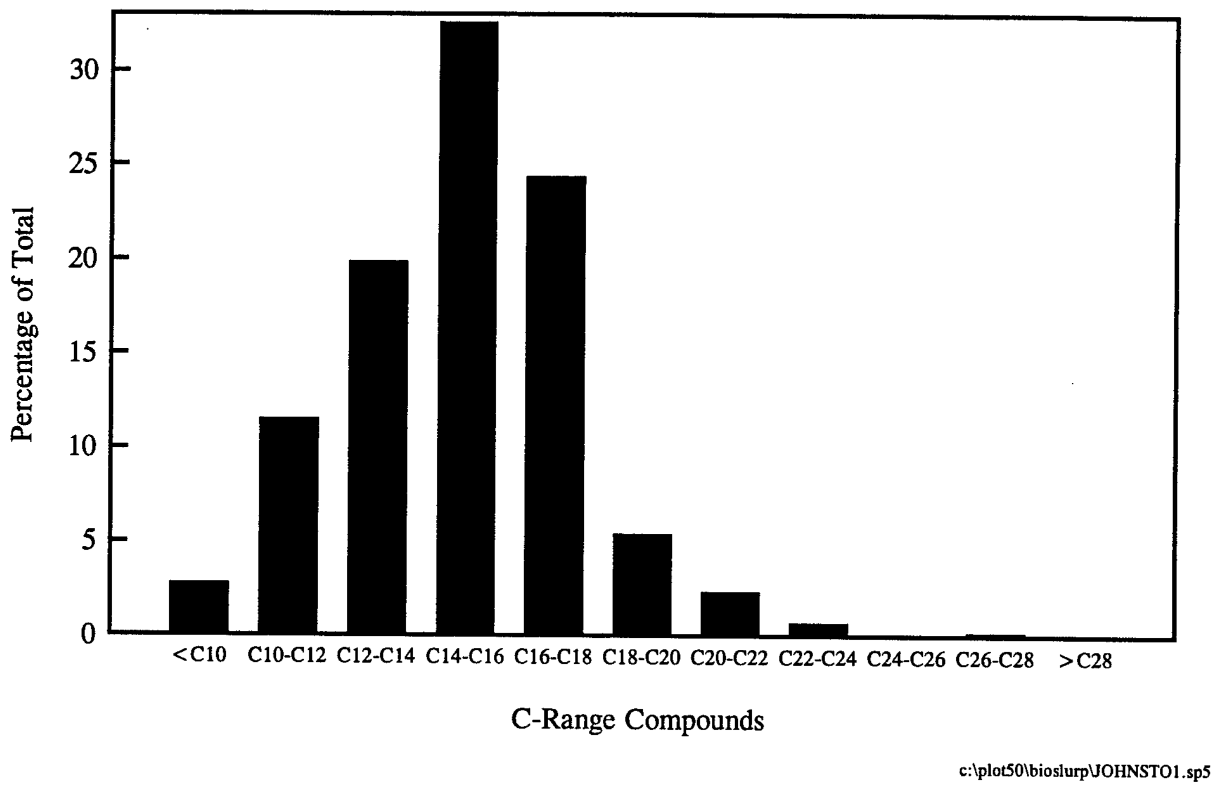

Figure 9. **Distribution of C-Range Compounds in Extracted LNAPL at the Storage Tank 49 Site, Johnston Atoll**

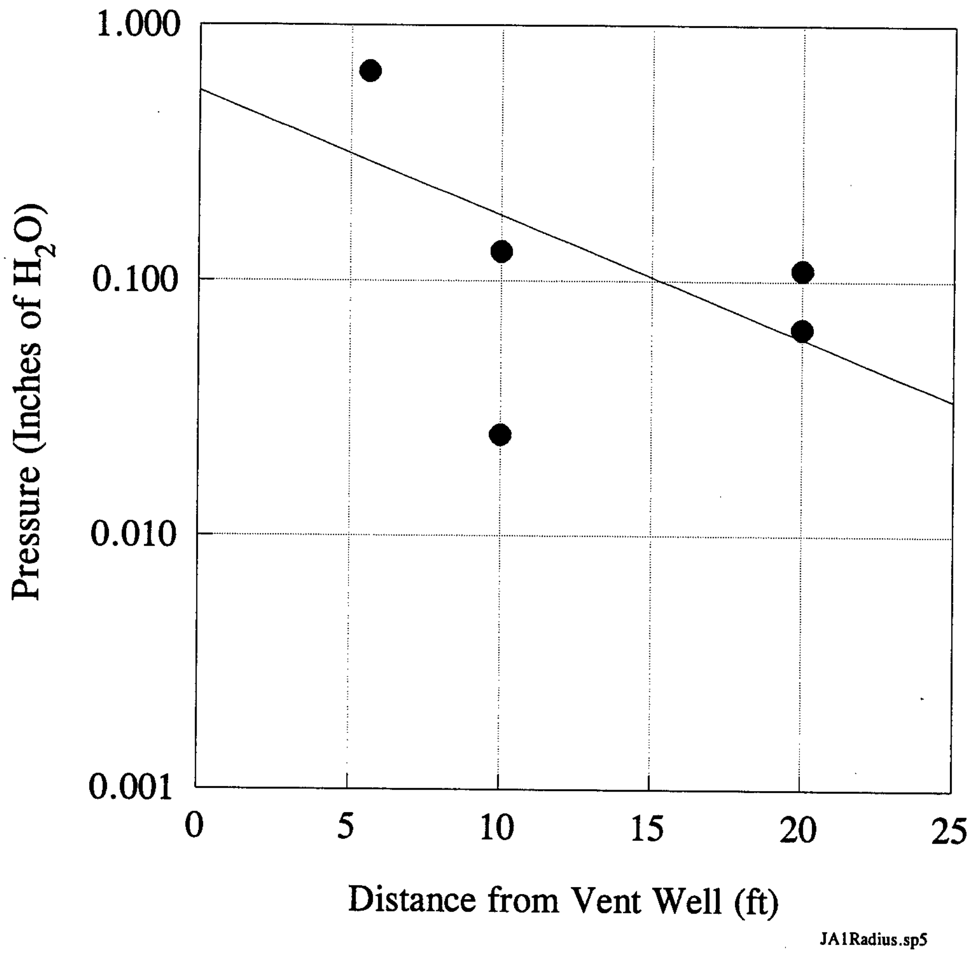

Figure 10. **Soil Gas Pressure Change as a Function of Distance During the Soil Gas Permeability Test**

4.5.2 In Situ Respiration Test Results

Results from the in situ respiration test are presented in Table 12. Oxygen depletion was relatively rapid, with oxygen utilization rates ranging from 0.24 to 0.50 $\%O_2$/hr. Biodegradation rates ranged from 60 to 122 mg/kg/day. The helium concentration was steady, indicating that leakage and diffusion were insignificant.

Table 12. In Situ Respiration Test Results at the Storage Tank 49 Site, Johnston Atoll

Monitoring Point	Oxygen Utilization Rate (%/hr)	Biodegradation Rate (mg/kg/day)
JA4-MPA-4.5	0.50	8.0
JA4-MPC-2.0	0.24	3.9
JA4-MPC-4.5	0.34	5.5

5.0 DISCUSSION

Skimmer pumping and drawdown pumping were not as effective as bioslurping at recovering LNAPL from this site. Ratios of groundwater to LNAPL extracted were high in comparison to results from the bioslurper pump test, except during the initial skimmer pump test. During the bioslurper pump test, LNAPL recovery was high initially, with an average rate of 180 gallons/day. LNAPL recovery rates decreased after the first day, with rates ranging from 24 to 40 gallons/day during the remainder of the test. The average LNAPL recovery rate throughout testing was 56 gallons/day.

Soil gas concentrations were measured at monitoring points during the bioslurper pump test to determine whether the vadose zone was being oxygenated. Oxygen concentrations increased significantly at monitoring points JA4-MPA and JA4-MPB at the shallow depths (Table 7). Oxygen concentration at monitoring point JA4-MPA-4.5 did not change during testing, which may be due to an area of low permeability. The bioslurper system did not oxygenate deeper soils at monitoring

SITE-SPECIFIC TEST PLAN FOR BIOSLURPER TESTING AT JOHNSTON ATOLL DNA, NORTH PACIFIC (A002)
CONTRACT NO. F41624-94-C-8012

FINAL

to

U.S. Air Force CEE
Technology Transfer Division
(AFCEE/ERT)
8001 Arnold Drive
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for

HQ PACAF

May 19, 1995

by

Battelle
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Columbus, OH 43201

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APPENDIX A

SITE-SPECIFIC TEST PLAN FOR BIOSLURPER FIELD ACTIVITIES AT JOHNSTON ATOLL

SITE-SPECIFIC TEST PLAN FOR BIOSLURPER TESTING AT JOHNSTON ATOLL DEFENSE NUCLEAR AGENCY, NORTH PACIFIC

to

U.S. Air Force CEE
Technology Transfer Division
Brooks AFB

May 19, 1995

1.0 INTRODUCTION

The Air Force Center for Environmental Excellence Technology Transfer Division is conducting a nationwide application of an innovative technology for free-product recovery and soil bioremediation. The technology tested in the Bioslurper Initiative is vacuum-enhanced free-product recovery/ bioremediation (bioslurping). The field test and evaluation are intended to demonstrate the initial feasibility of bioslurping by measuring system performance in the field. The Bioslurper Initiative has been designed to evaluate the effectiveness of biosurping as a light, nonaqueous-phase liquid (LNAPL) recovery technology relative to conventional gravity-driven recovery technologies. System performance parameters, mainly free-product recovery, will be determined at numerous sites. Field testing will be performed at many sites to determine the effects of different organic contaminant types and concentrations and different geological conditions on bioslurping effectiveness.

Plans for the field test activities are presented in two documents. The first is the overall test plan and technical protocol for the entire program, titled *Test Plan and Technical Protocol for Bioslurping* (Battelle, 1995). The overall plan is supplemented by plans specific to each test site. The concise site-specific plan effectively communicates vapor and aqueous discharge rates for compliance with regulatory issues specific to the base.

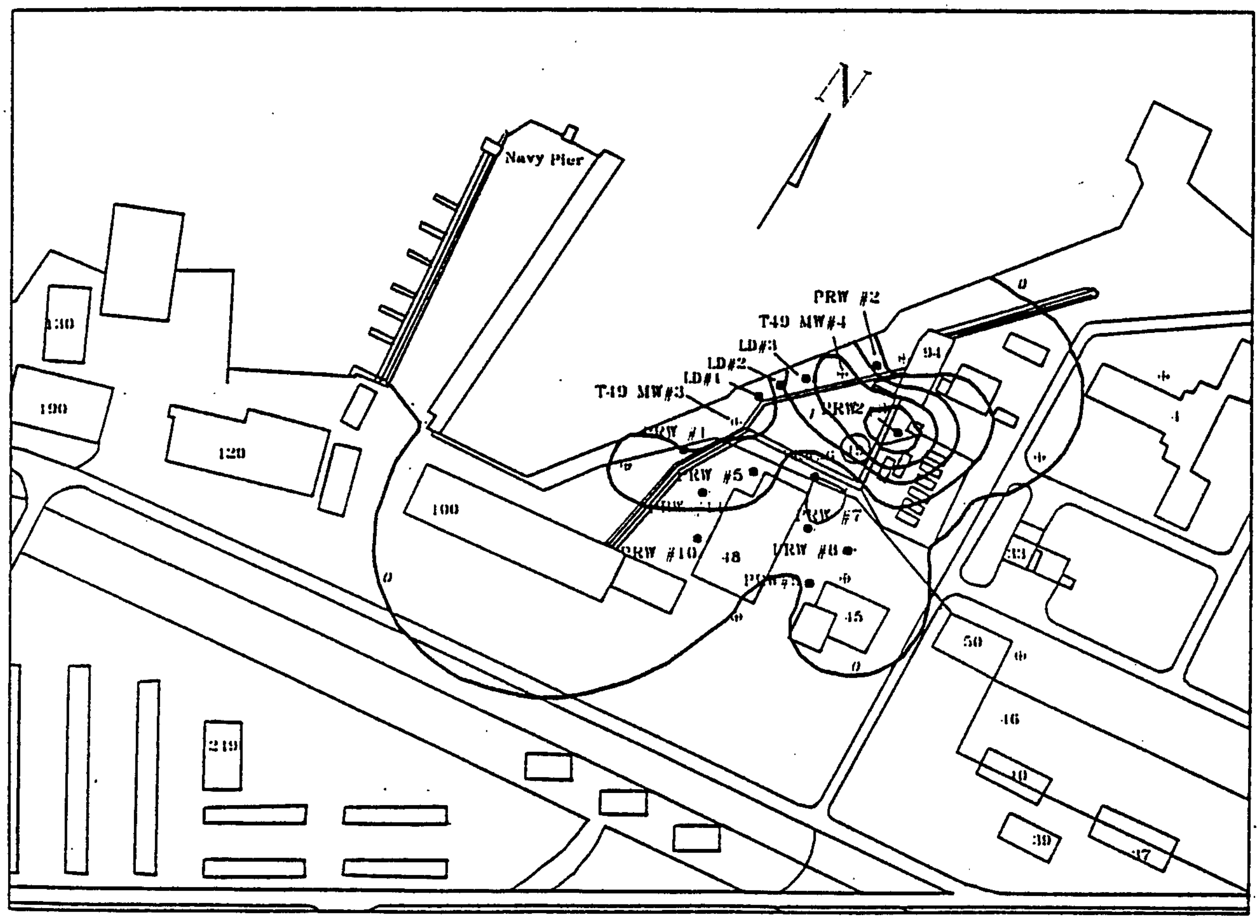
The overall test plan and protocol was developed as a generic plan for the Bioslurper Initiative to improve the accuracy and efficiency of test plan preparation and ensure consistent data collection across all test sites. The field program requires installation and operation of the bioslurping system supported by a wide variety of site characterization, performance monitoring, and chemical analysis activities. The basic methods to be applied from site to site do not change. Preparation and review of the overall plan allows efficient documentation and review of the basic approach to the test program. Peer and regulatory review were performed for the overall plan to ensure the credibility of the overall program.

This letter report is the site-specific supplement for Johnston Atoll Defense Nuclear Agency (DNA), North Pacific. It was prepared based on site-specific information received by Battelle from Johnston Atoll DNA and other pertinent site-specific information to support the generic test plan.

Site-specific information for Johnston Atoll DNA included data for the Storage Tank #49 Site. An initial review of the data indicates that the area surrounding Tank #49 is the most likely candidate for the bioslurper pilot test. Specifically, Well No. PRW3 and Well No. PRW11 appear to be good candidates. If these wells are found to be unsuitable for testing, one of the 17 other free-product recovery wells in the area will be chosen.

2.0 SITE DESCRIPTION

The site of interest is Storage Tank #49. The LNAPL contaminant is No. 2 Fuel Oil. Figure 1 shows the Storage Tank #49 Site, including the monitoring wells in the vicinity and the extent of the free-product plume. Table 1 summarizes the LNAPL recovery data taken from an LNAPL skimming system currently in use at the Tank #49 site. From these data, the wells that are most likely to yield significant amounts of free product have been identified. During the 1994 skimmer pump tests performed at the site, well #PRW3 and #PRW11 each averaged a recovery rate of approximately 13 gallons per week and are the most likely candidate wells for the bioslurper pilot test.



Legend

● Product Recovery Well

⁺ Monitoring Well

— Denotes extent of the free-product plume contaminating the Storage Tank #49 site (October 1993).

Scale
0 100 200 300
FEET

Figure 1. Location of Areas of Interest for Bioslurper Testing at Johnston Atoll DNA.

Table 1. LNAPL Recovery Data for Wells at the Tank #49 Site

	FREE PRODUCT RECOVERY (Gallons/Week)																		
Date	PRW1	PRW2	PRW3	PRW4	PRW5	PRW6	PRW7	PRW8	PRW9	PRW10	PRW11	PRW12	T49MW3	T49MW4	LD1	LD2	LD3	PADS	MOUSE
10/11/93	—	20	25	NP	5	10	5	5	NP	5	12	—	50	—	—	—	—	17	0
10/18/93	—	0	25	NP	10	2	5	5	NP	5	8	—	50	—	—	—	—	50	9
10/23/93	—	5	15	NP	0	3	5	5	NP	0	25	—	50	—	—	—	NP	15	0
10/30/93	—	5	3	NP	5	0	0	0	NP	5	25	—	50	—	NP	—	NP	10	0
11/08/93	—	5	2	NP	0	3	0	0	NP	0	0	—	50	—	5	NP	NP	11	1
11/13/93	6	3	0	NP	0	17	6	6	NP	0	0	—	21	—	NP	NP	15	76	12
11/28/93	1	26	0	NP	0	2	1	1	NP	0	0	—	19	—	NP	NP	0	0	3
12/05/93	2	8.5	20	NP	0	8	3	3	NP	0	3	—	67	—	NP	NP	0	0	0
12/12/93	0	4	0	NP	0	17	0	0	NP	0	2	—	8.5	—	NP	NP	0	14	0
12/19/93	4	7.5	0	NP	0	0	0	0	NP	0	20	—	4.5	—	NP	NP	0	95	16.5
12/26/93	0	7	10	NP	0	0	0	3	NP	0	0	—	4	—	NP	NP	0	28	5
01/02/94	4	28	14	NP	0	2	0	0	NP	0	11	—	22	—	NP	NP	0	162	11
01/09/94	4	13	9	NP	0	2	3	1	NP	0	15	—	17	—	NP	NP	0	28	2
01/15/94	2	5	14	NP	0	13	0	0	NP	0	1	—	5	—	NP	NP	0	35	0
01/22/94	1	5	13	NP	0	3	1	2	NP	0	8	—	10	—	NP	NP	0	12	0
01/29/94	7	9	6	NP	0	0	1	1	NP	0	7	—	19	—	NP	NP	0	40	0
02/05/94	0	15	13	NP	0	0	0	0	NP	0	18	—	8	—	NP	NP	0	15	1.5
02/12/94	3	13	9	NP	2	0	1	1	NP	0	10	1	11	5	NP	NP	—	57	2
02/19/94	0	14	16	NP	1	7	2	0.5	NP	0	17	0.5	13.5	0	NP	NP	—	17	0
02/26/94	1	22	12	NP	1.5	9	4	1.5	NP	0	17	0	18.5	2.5	NP	NP	—	60	7.5
03/05/94	14.5	14	13	NP	1	11.5	2.5	1	NP	0	38	0.5	27.5	2.5	NP	NP	—	92	6.5
03/12/94	3	23.5	11.5	NP	0.5	0	4.5	0	NP	0	14	0	14	2.5	NP	NP	—	45	12.5
03/19/94	0.5	11.5	8	NP	1.5	8.5	0	2.5	NP	0	17.5	0	10.5	2	NP	NP	—	30	0.25
03/26/94	3	6	4.5	NP	0	3	0	0	NP	0	0.5	0	17	2.5	NP	NP	—	47	0.25
04/02/94	1.5	30	23	NP	0	8.5	0	0	NP	0	22.5	0	0.5	3	NP	NP	—	29	0
04/09/94	8	4.5	4.5	NP	0	2.5	0	0	NP	0	7	NP	0	0	NP	NP	26	14	—
04/16/94	10	5	4	NP	0	6.5	0	0	NP	NP	5.5	NP	0	0.5	NP	NP	5	15	1
04/23/94	—	—	—	NP	—	—	—	—	NP	NP	—	NP	—	—	NP	NP	—	—	—
04/30/94	—	—	—	NP	—	—	—	—	NP	NP	—	NP	—	—	NP	NP	—	—	—
05/07/94	2.5	10.5	13.5	NP	0	4.5	0	0	NP	NP	1	NP	11.5	2	NP	3	6.5	—	—
05/14/94	1.5	14	9	NP	0	8	2	1	NP	NP	17.5	NP	18	1.5	NP	8	11	10	22
05/21/94	3.5	8	21.5	NP	0	4.5	0	1	NP	NP	20	NP	11.5	3	NP	4.5	7.5	15	10.5
05/28/94	2.5	15	25	NP	0	10	0	0	NP	NP	12.5	NP	21	1.5	NP	1.5	8	18	4
06/04/94	0	41.5	8.5	NP	0	6	0	0	NP	NP	9	NP	7.5	2.5	NP	0.5	4.5	0	0
06/11/94	0	20	14	NP	0	18.5	0	NP	NP	NP	28	NP	14.5	NP	NP	5.5	8.5	3	10
06/18/94	8	6	21.5	NP	NP	1	4	NP	NP	NP	18	NP	8	NP	NP	2	6	3	1
06/25/94	0	11	18	NP	NP	7.5	4	NP	NP	NP	15.5	NP	0	1.5	NP	—	—	27	1
07/02/94	0	8	18	NP	NP	0.5	3	NP	NP	NP	16.5	NP	2	2	NP	—	8	0	0
07/09/94	0	16.5	21	NP	NP	7	2	NP	NP	NP	16.5	NP	5	3.5	NP	—	8.5	0	0
07/16/94	0	2.5	25	NP	NP	8.5	—	NP	NP	NP	15	NP	NP	2.5	NP	—	4	0	0

NP indicates wells were not pumped - insufficient free product in wells

2.1 Site Geology

The soils on Johnston Atoll typically consist of compacted crushed coral. Surface vegetation is sparse, consisting of grasses within the bermed area of Tank #49. The Tank #49 site is located adjacent to the lagoon. The shoreline is protected by a vertical concrete seawall, extending 15 ft below ground surface.

2.2 Site Contamination

Currently, the area is operational, with all petroleum product storage tanks still in use. No. 2 fuel oil was stored in both Tank #49 and the day-use tank until November 1991, when the island's fuel oil uses were converted to JP-5 jet fuel.

Leaks and spills within the Tank #49 site have been poorly documented, but it is believed that fuel may leaked from the tank from the 1960s to 1987. In 1987, a leak occurred from the base of Tank #49. Site staff who witnessed the resultant contamination estimated that the volume of fuel spilled ranged from 5,000 to 20,000 gal. Release of the product to the lagoon through cracks in the seawall has been persistent. A fuel sheen is noticeable at low tides on the surface of the lagoon.

3.0 PROJECT ACTIVITIES

The following field activities are planned for the bioslurper pilot test at Johnston Atoll DNA. Additional details about the activities are presented in the *Test Plan and Technical Protocol for Bioslurping* (Battelle, 1995). Table 2 shows the schedule of activities for the Bioslurper Initiative at Johnston Atoll DNA.

3.1 Mobilization to the Site

After the site-specific test plan is approved, Battelle staff will mobilize equipment. The Base Point of Contact (POC) will have been asked in advance to find a suitable holding facility to receive the bioslurper pilot test equipment so that the equipment will be easily accessible to the Battelle staff when they arrive. The exact mobilization date will be confirmed with the Base POC as far in advance of fieldwork as is possible. All equipment will be shipped via air express to Johnston Atoll DNA prior to staff arrival. The Battelle POC will provide the Air Force POC with information on each Battelle employee who will be on site. Battelle personnel will be mobilized to the site after receiving confirmation that all equipment has been received by Johnston Atoll DNA.

3.2 Site Characterization Tests

3.2.1 Baildown Tests

The baildown test is the primary test for selection of the bioslurper test well. Baildown tests will be performed at wells that contain measurable thicknesses of LNAPL to estimate the LNAPL recovery potential at those wells. Baildown tests will be performed on well #PRW3 and #PRW11, which have shown persistent measurements of LNAPL thickness during previous site characterization tests. In most cases, the well exhibiting the highest rate of LNAPL recovery will be selected for the bioslurper

Table 2. Schedule of Bioslurper Test Activities

Pilot Test Activity	Schedule
Mobilization	day 1-2
Site Characterization	day 2-3
Baildown Tests and Product/Groundwater Interface Monitoring	
Soil-Gas Survey (limited)	
Monitoring Point Installation (3 MP)	
Soil Sampling (TPH, BTEX, physical characteristics)	
System Installation	day 2-3
Test Startup	day 3
Skimmer Test (2 days)	day 3-4
Bioslurper Vacuum Extraction (4 days)	day 6-9
Soil-Gas Permeability Testing	day 6
Skimmer Test (continued) (1 day)	day 10
In Situ Respiration Test — air/helium injection	day 10
In Situ Respiration Test — monitoring	day 11-16
Drawdown Pump Test (2 days)	day 11-12
Demobilization/Mobilization	day 13-14

extraction well. Detailed procedures for the baildown tests are provided in Section 5.6 of the Bioslurping Protocol.

3.2.2 Soil-Gas Survey (Limited)

A small-scale soil-gas survey will be conducted to identify the best location for installation of the bioslurping system soil-gas monitoring points. The soil-gas survey will be conducted in areas where historical site data indicate the highest contamination levels. In Table 1, the wells exhibiting substantial recovery rates appear in bold type. The area around these wells will be surveyed to select the locations for installation of soil gas monitoring points. Soil-gas monitoring point placement will be concentrated around areas that exhibit the following soil-gas characteristics.

1. Relatively high total petroleum hydrocarbon (TPH) concentrations (>10,000 ppmV).

2. Relatively low oxygen concentrations (between 0% and 2%).

3. Relatively high carbon dioxide concentrations (depending on soil type, between 2% and 10% or greater).

For further information about the soil-gas survey, consult Section 5.2 of the Bioslurping Protocol.

3.2.3 Monitoring Point Installations

Monitoring points must be installed to determine the radius of influence that the free-product recovery system has on vadose zone soils. A general arrangement of the bioslurping well and monitoring points at the Storage Tank #49 Site is shown in Figure 2.

Upon conclusion of the initial soil-gas survey, baildown tests, at least three soil-gas monitoring points will be installed (unless existing monitoring points can be identified and used). These monitoring points should be located in highly contaminated soils within the free-phase plume and should be positioned to allow detailed monitoring of the in situ changes in soil-gas composition caused by the bioslurper system. The components of a soil-gas monitoring point are shown in Figure 3. Figure 4 shows a conceptual arrangement for soil-gas monitoring points at Tank #49, Well No. PRW3, the likely candidate for the bioslurper test installation. Information on monitoring point installation can be found in Section 4.2 of the Bioslurping Protocol.

3.2.4 Soil Sampling

Soil sampling will be conducted to identify soil and contaminant characteristics at the bioslurper pilot test site. Soil samples from the chosen site will be collected from boreholes advanced for monitoring point installation. Two soil samples will be collected at the proposed test site. The samples will be collected from one borehole through the capillary fringe.

Soil samples from each boring will be analyzed for particle-size distribution; bulk density; porosity; moisture content; benzene, toluene, ethylbenzene, and xylenes (BTEX); and total petroleum hydrocarbons (TPH). Section 5.5.1 of the Bioslurping Protocol will be consulted for information on the field measurements and sample collection procedures for soil sampling.

3.3 Bioslurper System Installation and Operation

Once the well to be used for the bioslurper test installation at Johnston Atoll DNA has been identified, the 3-hp bioslurper pump and support equipment will be installed and the pilot test initiated. As stated previously, Well No. PRW3 is likely to be selected.

3.3.1 System Setup

Figure 5 shows a flow diagram of the bioslurper process. Figure 6 is a generic diagram of the bioslurper extraction well that will be configured using an existing recovery well at Johnston Atoll DNA.

Before LNAPL recovery tests are initiated, all relevant baseline field data will be collected and recorded. These data will include soil-gas concentrations, initial soil-gas pressures, depth to groundwater, and LNAPL thickness. Ambient soil and the atmospheric conditions (e.g., temperature, humidity, barometric pressure) also will be recorded. All emergency equipment (i.e., emergency shutoff switches and fire extinguishers) will be installed and checked for proper operation at this time. Upon completion of the initial site characterization tests, all equipment will be mobilized from the holding facility to the test site, and the bioslurper system will be assembled.

A clear, level 20- by 10-ft area near the well selected will be identified to station the equipment required for bioslurper system operation. For more information on the bioslurper system installation,

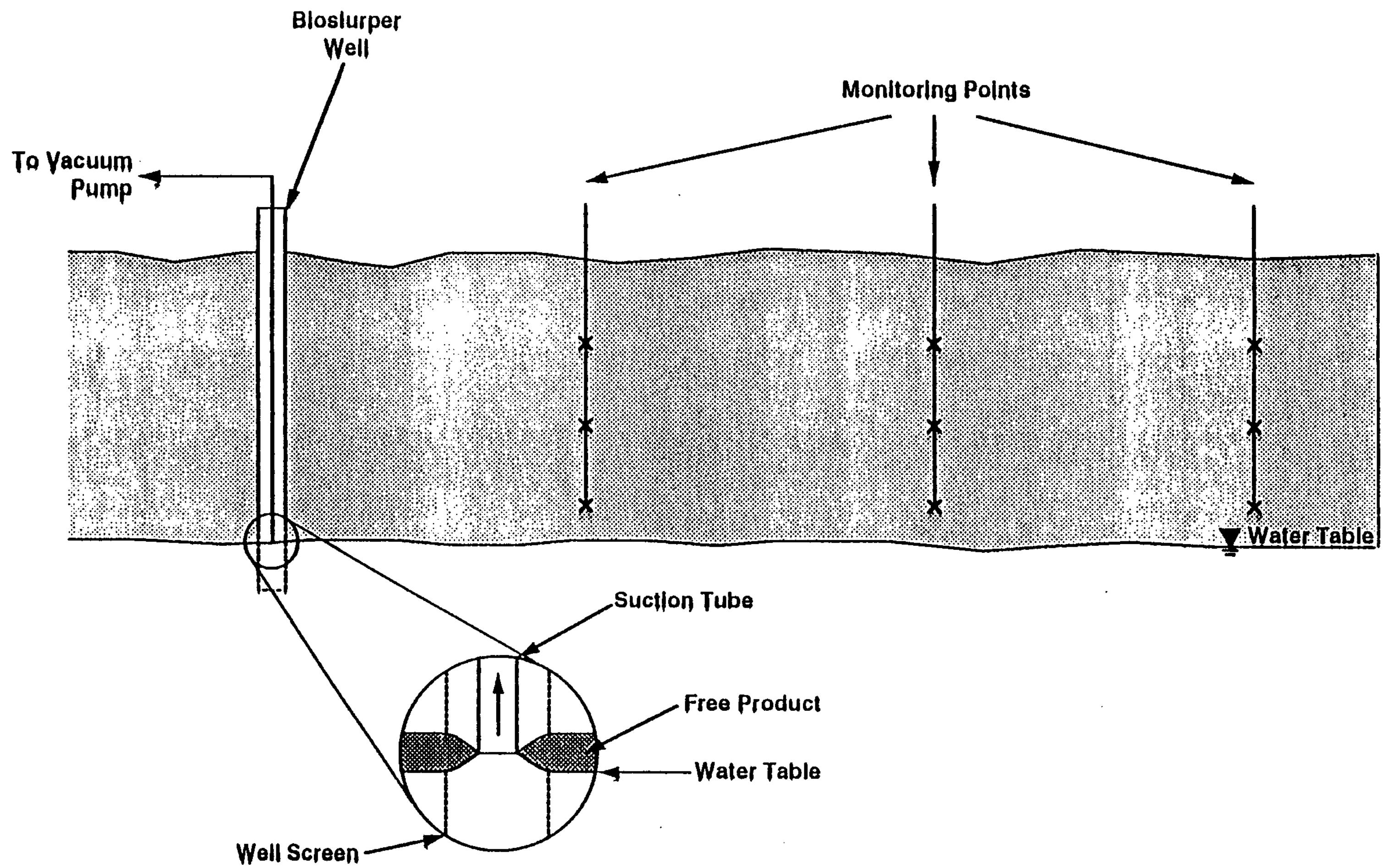


Figure 2. General Bioslurper Well and Monitoring Point Arrangement.

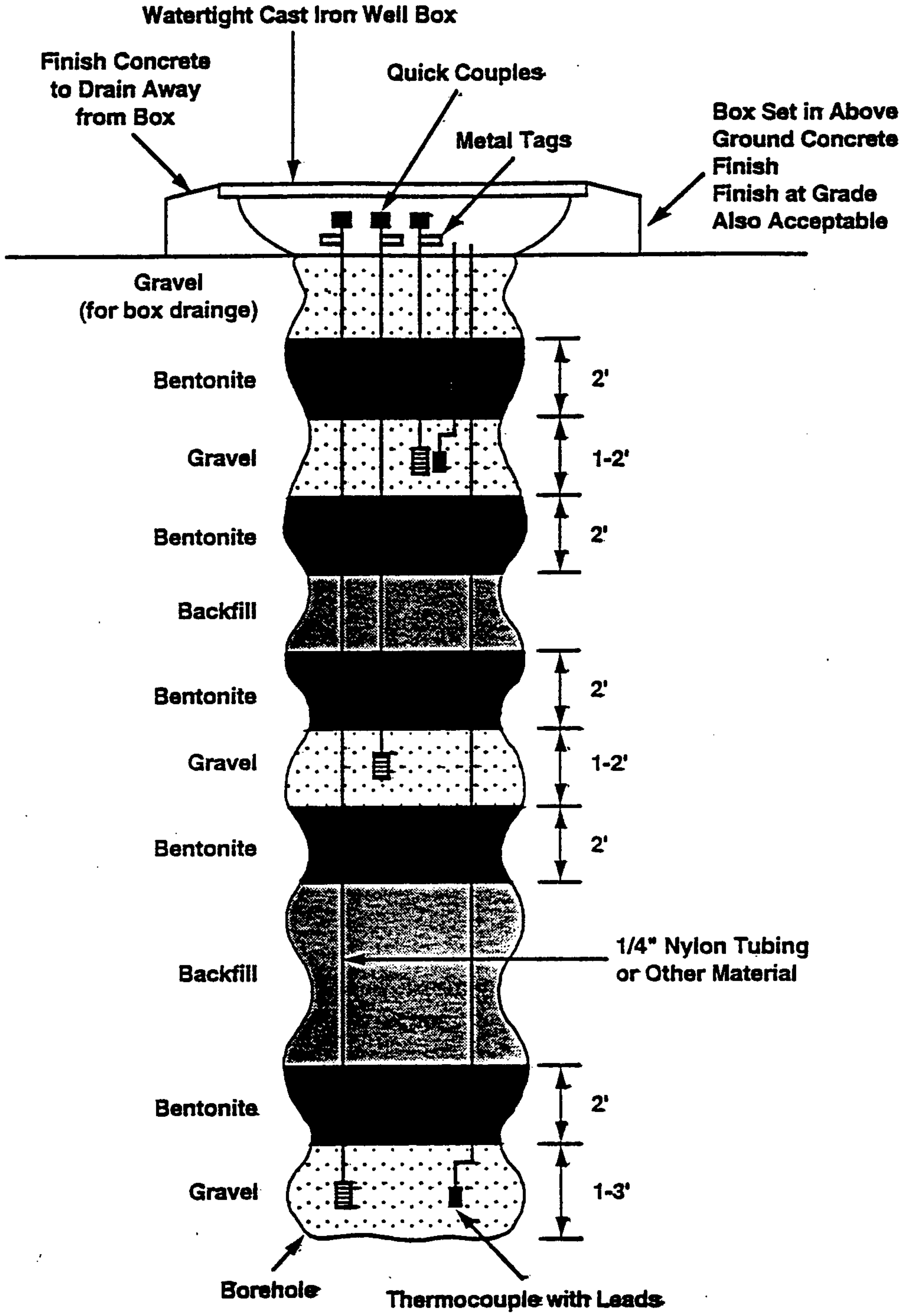


Figure 3. Diagram of a Typical Bioslurper Soil-Gas Monitoring Point

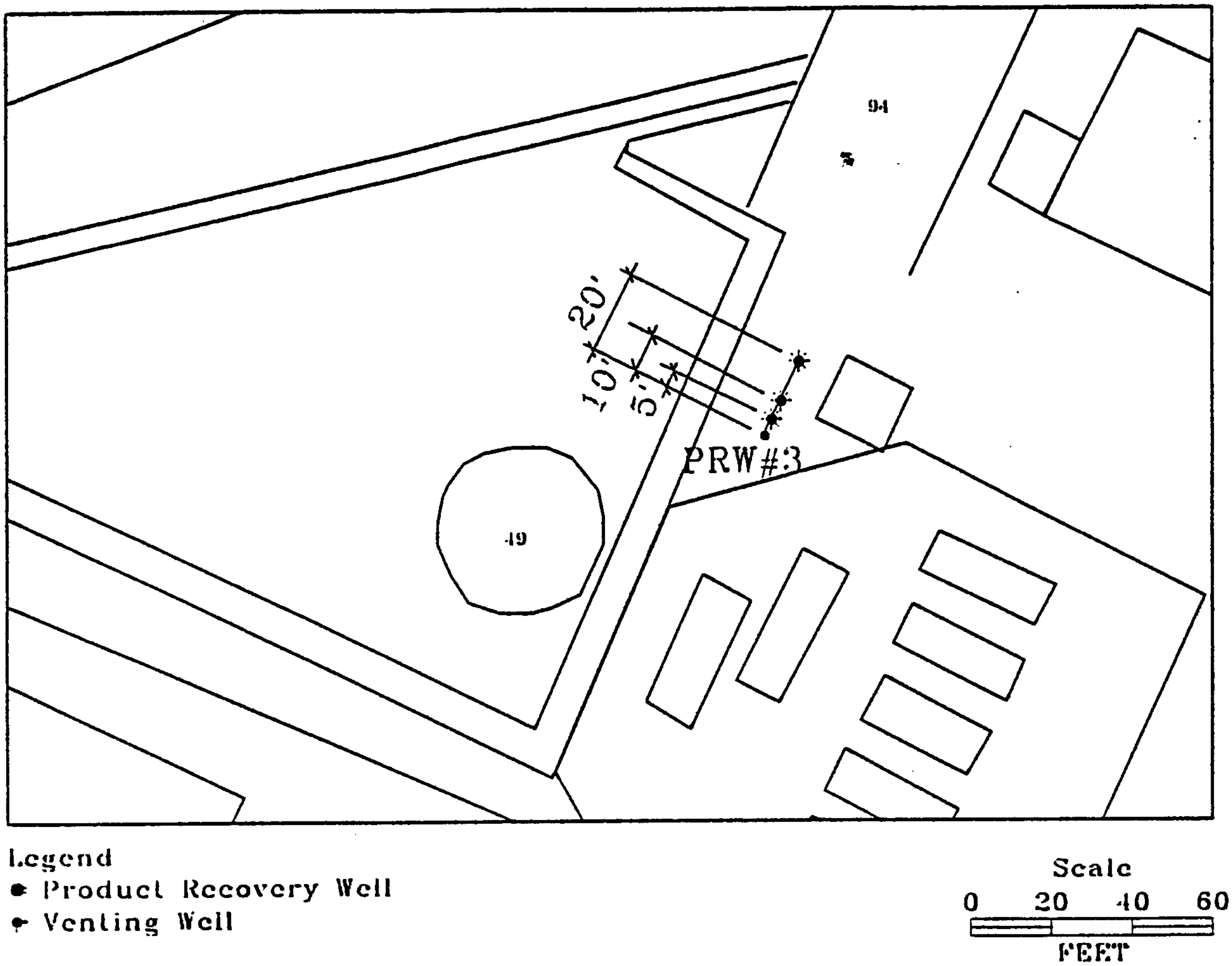


Figure 4. Conceptual Arrangement of Bioslurper Soil-Gas Monitoring Points for Johnston Atoll DNA POL Depot

consult Section 6.0 of the Bioslurping Protocol.

3.3.2 System Shakedown

A brief startup test will be conducted to ensure that the system is properly constructed and operates safely. All system components will be checked for problems and/or malfunctions. A checklist will be provided to document the system shakedown.

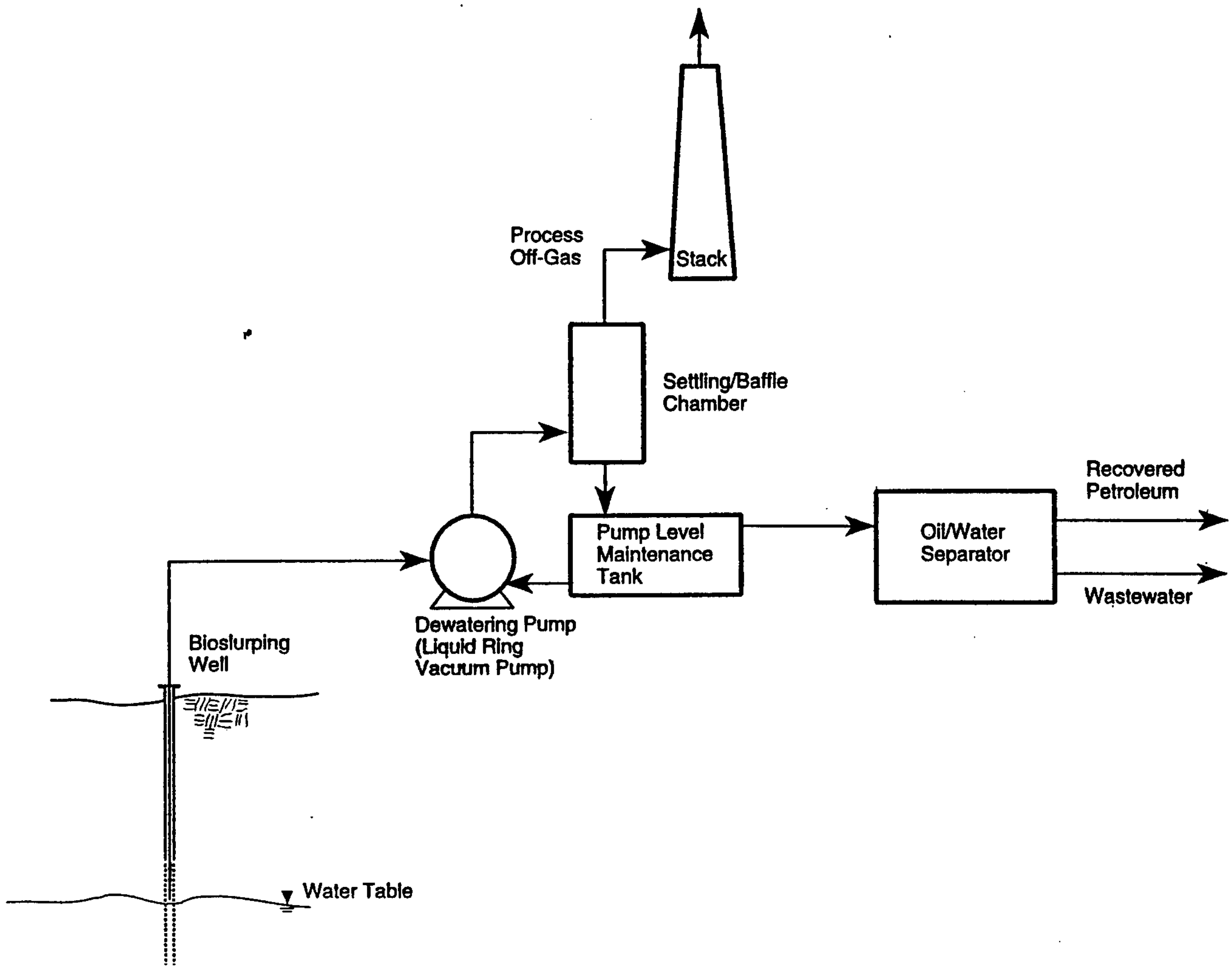


Figure 5. Bioslurper Process Flow.

3.3.3 System Startup and Test Operations

After installation is complete and the bioslurper system is confirmed to be operating properly, the LNAPL recovery tests will be started. The Bioslurper Initiative has been designed to evaluate the effectiveness of bioslurping as an LNAPL recovery technology relative to conventional gravity-driven LNAPL recovery technologies. The Bioslurper Initiative Protocol includes three separate LNAPL recovery tests: (1) a skimmer simulation test, (2) a vacuum-assisted bioslurper test, and (3) a groundwater drawdown LNAPL recovery test. The three recovery tests are described in detail in Section 7.3 of the Bioslurping Protocol.

Parameters measured during bioslurper operation are vapor discharge and aqueous effluent characterization, LNAPL recovery volume rates, vapor discharge volume rates, and groundwater discharge volume rates. Vapor monitoring will consist of intermittent on-line monitoring of TPH supplemented by two samples collected for detailed laboratory analysis. A total of two samples of aqueous effluent will be collected for analysis of BTEX and TPH content. Recovered LNAPL volume will be recorded using an in-line flow-totalizing meter. The off-gas discharge volume will be measured using a calibrated pitot tube, and the groundwater discharge volume will be recorded using

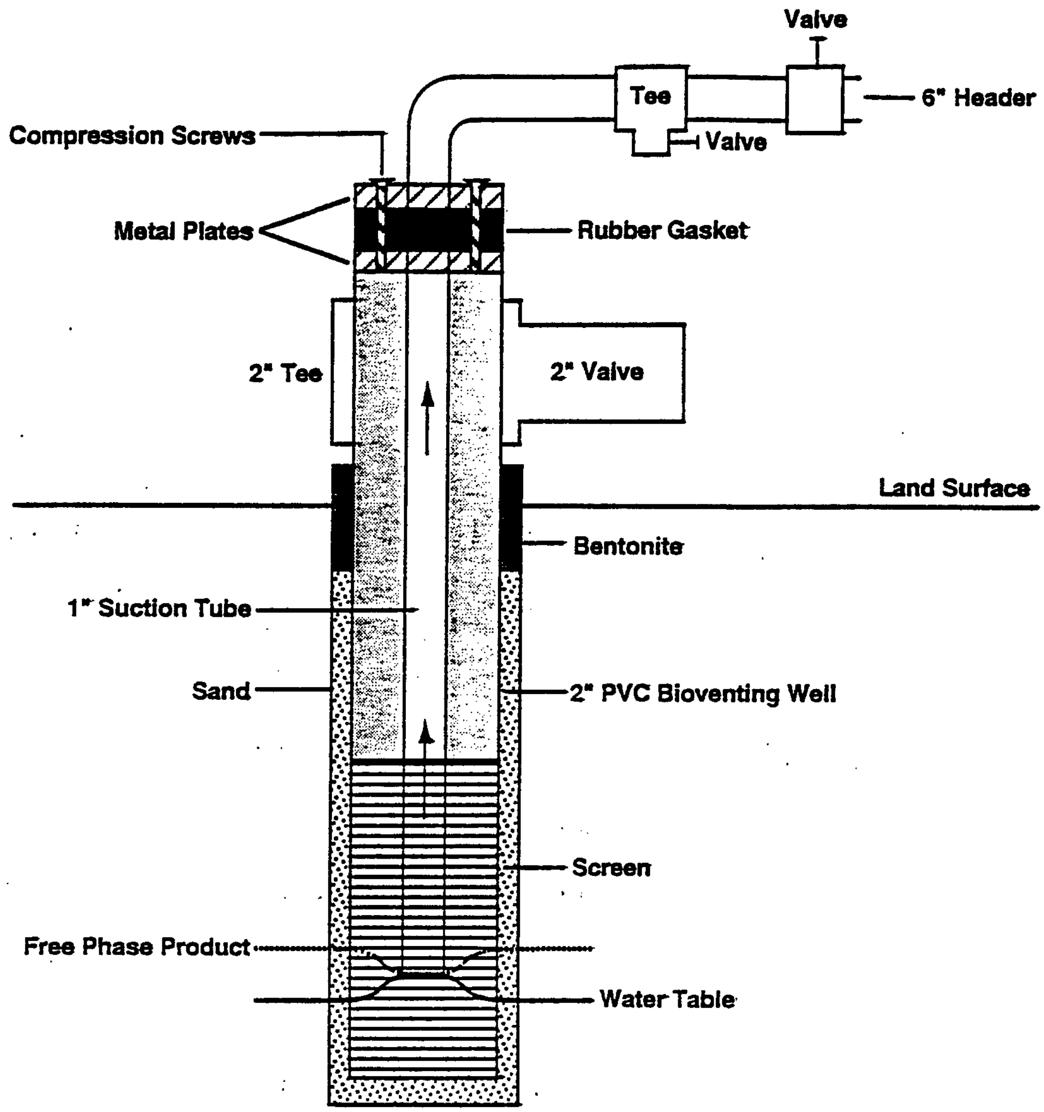


Figure 6. Diagram of a Typical Bioslurper Well.

an in-line flow-totalizing meter. Section 8.0 of the Bioslurping Protocol describes the process monitoring of the bioslurper system.

3.3.4 Soil-Gas Permeability Tests

A soil-gas permeability test will be conducted concurrently with startup of the vacuum-assisted bio-slurper operation. Soil-gas permeability data will support the process of estimating the vadose zone radius of influence of the bioslurper system. Soil-gas permeability results also will aid in determining the number of wells that will be required if it is decided to treat the site with a large-scale bioslurper system. The soil-gas permeability test method is described in Section 5.7 of the Bioslurping Protocol.

3.3.5 LNAPL and Water Level Monitoring

A well adjacent to the bioslurper pilot test extraction well will be used to monitor LNAPL and water level fluctuations in the site aquifer. This will be done by sealing the top of the well with a teflon seal, which will allow an oil/water interface probe to be used for measuring the LNAPL and water levels in the well without breaking the subsurface vacuum. Level measurements will be taken intermittently during the bioslurper pilot test.

3.3.6 In Situ Respiration Tests

The oxygen utilization rate will be used to estimate the biodegradation rate at the site. An in situ respiration test will be conducted after completion of the bioslurper operating tests. The in situ respiration test will involve injection of air and helium into selected soil-gas monitoring points followed by monitoring changes in concentration of oxygen, carbon dioxide, petroleum hydrocarbons, and helium in soil gas near the injection point. Measurement of the soil-gas composition typically will be conducted at 2, 4, 6, and 8 hours and then every 4 to 12 hours for about 2 days. Timing of the tests will be adjusted based on oxygen use rate. If oxygen depletion occurs rapidly, more frequent monitoring will be conducted. If oxygen depletion is slow, less frequent readings will be acceptable. Further information on the procedures and data collection for in situ respiration testing is given in Section 5.8 of the Bioslurping Protocol.

3.3.7 Extended Testing

The AFCEE/ERT has the option of extending the operation of the bioslurper system for up to 6 months if LNAPL recovery rates are promising and viable long-term vapor and aqueous discharge requirements have been identified. If extended testing is to be performed, additional site support will be required. The Air Force will need to provide electrical power for long-term operation of the bioslurper pump. Disposition of all generated wastes and routine operation and maintenance of the system will be the Air Force's responsibility. Battelle will provide technical support during the extended testing operation.

3.4 Demobilization

Once all necessary tests have been completed at the Johnston Atoll DNA site, the equipment will be disassembled by Battelle staff. The equipment then will be moved back to the holding facility, where it will remain until its next destination is determined. Battelle staff will be responsible for shipping the equipment to the next site before they leave Johnston Atoll.

4.0 BIOSLURPER SYSTEM DISCHARGE

4.1 Vapor Discharge Disposition

Battelle expects that the operation of the bioslurper test system at the Johnston Atoll site may require a waiver or a point source air release registration. The organic vapor discharge is estimated to be less than 3 lbs TPH/day. The organic vapor discharge concentration was estimated based on soil-gas data collected during a bioventing study performed at Tank #49 (*Bioventing Field Initiative at Johnston Island Field Command Defense Nuclear Agency, Johnston Atoll: Interim Report*, Battelle, 1993) and from previous bioslurper emission data (shown as Table 3). In addition, based on Battelle's

experience at bioventing sites contaminated with No. 2 Fuel Oil the discharge of benzene vapor is expected to be minimal, generally below detection. The organic vapor discharge rate should remain relatively constant throughout the pilot test. The vapor stream generated by the bioslurper system can be discharged directly to the atmosphere because of the short duration of the test and the low concentration levels of TPH and benzene in the stream. If a short-term (9-10 days pumping) waiver is required, a waiver is hereby requested.

Table 3. Benzene and TPH Discharge Levels at Previous Bioslurper Test Sites

Site Location	Fuel Type	Extraction Rate (scfm)	Benzene (ppmv)	TPH (ppmv)	Benzene Discharge (lb/day)	TPH Discharge (lb/day)
Wright-Patterson AFB	Jet Fuel	3	nd*	595	0.0	1.0
Bolling AFB (Site #1)	No. 2 Fuel Oil	4	0.2	153	0.0003	0.009
Bolling AFB (Site #2)	Gasoline	21	370	70,000	2.3	470.1
Travis AFB	Jet Fuel	20	100	10,800	0.58	126.4
Andrews AFB	No. 2 Fuel Oil	8	16	2,000	0.001	0.2

To ensure the safety and regulatory compliance of the bioslurper system, vapor discharge samples (TPH, O_2, and CO_2) will be collected periodically throughout the bioslurper pilot test. Also, field soil-gas screening instruments will be used to monitor vapor discharge concentration variability. The volume of vapor discharge will be monitored daily using air flow instruments. If state regulatory requirements will not permit the expected amount (less than 3 lbs/day) of organic vapor discharge to the atmosphere, the Base POC should inform AFCEE and Battelle so that alternative plans can be made prior to mobilization to the site. It is expected that the operation of the bioslurper pilot test equipment will pose no health risks due to the location and rate of the system's vapor discharge. Table 4 presents information typically required to complete an air release registration form.

Table 4. Air Release Summary Information

Data Item	Air Release Information
Contractor Point of Contact	Jeff Kittel, (614) 424-6122
Contractor address	Battelle 505 King Avenue Columbus, Ohio 43201-2693
Estimated total quantity of petroleum product to be recovered	TBD
Description of petroleum product to be recovered	Diesel
Planned date of test start	TBD
Test duration	9 days (active pumping)
Maximum total quantity of VOC release	<3 lb/day TPH, <1 lb/day benzene
Stack height above ground level	10 ft

4.2 Aqueous Influent/Effluent Disposition

The flowrate of groundwater pumped by the bioslurper will be less than 5 gpm. If a groundwater pumping waiver or registration permit is required in the North Pacific, the base POC will inform Battelle of the steps necessary to obtain the waiver or permit. If not, approval for on-site sanitary sewer discharge will be obtained.

Operation of the bioslurper system will generate an aqueous waste discharge that will be passed through an oil/water separator. The intention of Battelle staff will be to dispose of the wastewater by discharge directly to the Base wastewater treatment facility. If existing Base wastewater channels can be used, no National Pollutant Discharge Elimination System (NPDES) or other water discharge permits will be required.

4.3 Free-Product Recovery Disposition

The bioslurper system will recover free-phase product from the pilot tests performed at Johnston Atoll DNA. Free product recovered by the bioslurping tests will be turned over to the Base for disposal and/or recycling. The volume of free product recovered from the Base will not be known until the tests have been performed. The maximum recovery rate for this system is 5 gpm, but the actual rate of LNAPL recovery will be much lower.

5.0 SCHEDULE

The schedule for the bioslurper fieldwork at Johnston Atoll DNA will depend on approval of the project test plans. Battelle will determine a definitive schedule as soon as possible after approval is received. Battelle will have two to three staff members on site for approximately 2 weeks to conduct all necessary pilot testing. At the conclusion of the field testing at Johnston Atoll DNA, all staff will return their

Base passes. Battelle staff will remove all bioslurper field testing equipment from the Base before leaving Johnston Atoll.

6.0 PROJECT SUPPORT ROLES

This section outlines the some of the major functions of personnel from Battelle, Johnston Atoll DNA, and AFCEE during the bioslurper field test.

6.1 Battelle Activities

The obligations of Battelle in the Bioslurper Initiative at Johnston Atoll DNA will be to supply all staff and equipment necessary to perform all the tests on the bioslurper system. Battelle also will provide technical support in the areas of water and vapor discharge permitting, digging permits, staff support during the extended testing period, and any other technical areas that need to be addressed.

6.2 Johnston Atoll DNA Support Activities

To support the necessary field tests at Johnston Atoll DNA, the Base must be able to provide the following:

a. Any digging permits and utility clearances that need to be obtained prior to initiation of the fieldwork. Any underground utilities should be clearly marked to reduce the chance of utility damage and/or personal injury during soil-gas probe and possible well installation. Battelle will not begin field operations without these clearances and permits.

b. The Air Force will be responsible for obtaining Base and site clearance for the Battelle staff that will be working at the Base. The Base POC will be furnished with all necessary information on each staff member at least 1 week prior to field startup.

c. Access to the local sanitary sewer must be furnished so that Battelle staff can discharge the bioslurper aqueous effluent directly to the Base treatment facility.

d. Regulatory approval, if required, must be obtained by the Base POC prior to startup of the bioslurper pilot test. As stated previously, it is unlikely that an air release waiver or a point source air release registration will be required for emissions of less than 3.0 lb/day. A waiver for pumping and discharging groundwater at a rate of 5 gpm is hereby requested. If any regulatory permits are required, they will need to be acquired prior to mobilization to the site. The Base POC will inform Battelle as to what permits will be required, and Battelle will assist the Base POC by providing the technical assistance necessary to prepare the regulatory approval documents.

e. The Base will be responsible also for the disposition of all waste generated from the pilot testing. Such waste includes any soil cuttings generated from drilling and all aqueous wastestreams produced from the bioslurper tests. All free product recovered from the bioslurper operation will be disposed of or

recycled by the Base. Battelle will provide technical assistance in disposing of the waste generated from the bioslurper pilot test.

f. The Health and Safety Plan for Johnston Atoll DNA will be finalized with information provided by the Base POC prior to field activities commencing. Table 5 is a checklist for the information required to complete the Health and Safety Plan.

6.3 AFCEE Activities

The Air Force Center for Environmental Excellence (AFCEE) POC will act as a liaison between Battelle and Johnston Atoll DNA staff. The AFCEE POC will ensure that all necessary permits are obtained and that the required space to house the bioslurper field equipment is found. The following is a listing of Battelle, AFCEE, and Johnston Atoll DNA staff who can be contacted in cases of emergency and/or if technical support is required during the bioslurper field initiative tests at Johnston Atoll DNA.

Battelle POCs	Jeff Kittel	614-424-6122
	Eric Drescher	614-424-3088
AFCEE POC	Patrick Haas	210-536-4314
Johnston Atoll POC	Mark Ingoglia	808-449-9236
Facility POCs		
General:	Danny Long	702-794-1384
	Mike Shotten	________
Water:	Cmdr. Aquello	505-846-8733
	Major Joe Kimball	505-846-5396

Table 5. Health and Safety Information Checklist

Emergency Contacts	**Name**	**Telephone Number**
Hospital Emergency Room:	________	________
Point of Contact:	________	________
Fire Department:	________	________
Emergency Unit (Ambulance):	________	________
Security:	________	________
Explosives Unit:	________	________
Community Emergency Response Coordinator:	________	________
Other:	________	________
Program Contacts Notify in case of emergency.		
Air Force AFCEE:	Patrick Haas	210-536-4314
	Mark Ingolia	808-449-9236
Battelle:	Jeff Kittel	614-424-6122
	Eric Drescher	614-424-3088
Other:	Mike Shotten	________
	Danny Long	702-794-1384
Emergency Routes	________	________
Hospital (maps attached)		
Other: ________		

APPENDIX B

LABORATORY ANALYTICAL REPORTS

@ AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

WORK ORDER #: 9506185

Work Order Summary

CLIENT:	Mr. Al Pollack Battelle Memorial Institute 505 King Avenue Columbus, OH 43201	**BILL TO:** Same
PHONE:	614-424-3753	**INVOICE #** 7276
FAX:	614-424-3667	**P.O. #**
DATE RECEIVED:	6/19/95	**PROJECT #** G462201 Bioslurper
DATE COMPLETED:	6/27/95	**AMOUNT$:** $260.00

FRACTION #	NAME	TEST	RECEIPT VAC./PRES.	PRICE
01A	JA 4-STK-1	TO-3	1.0 "Hg	$120.00
02A	JA 4-STK-2	TO-3	1.0 "Hg	$120.00
03A	Lab Blank	TO-3	NA	NC

Misc. Charges 1 Liter SUMMA Canister Preparation (2) @ $10.00 each. $20.00

CERTIFIED BY: Linda J. Freeman
Laboratory Director

DATE: 6/27/95

180 BLUE RAVINE ROAD, SUITE B FOLSOM, CA 95630
(916) 985-1000 • (800) 985-5955 • FAX (916) 985-1020

AIR TOXICS LTD.

SAMPLE NAME: JA 4-STK-1

ID#: 9506185-01A

EPA METHOD TO-3

(Aromatic Volatile Organics in Air)

GC/PID

File Name:	6062314		Date of Collection: 6/10/95	
Dil. Factor:	44		Date of Analysis: 6/23/95	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
Benzene	0.044	0.14	0.54	1.8
Toluene	0.044	0.17	2.9	11
Ethyl Benzene	0.044	0.19	1.5	6.6
Total Xylenes	0.044	0.19	1.3	5.7

TOTAL PETROLEUM HYDROCARBONS

GC/FID

(Quantitated as Jet Fuel)

File Name:	6062314		Date of Collection: 6/10/95	
Dil. Factor:	44		Date of Analysis: 6/23/95	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
TPH* (C5+ Hydrocarbons)	0.44	2.9	850	5500
C2 - C4** Hydrocarbons	0.44	0.80	0.92	1.7

*TPH referenced to Jet Fuel (MW=156)

**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: JA 4-STK-2

ID#: 9506185-02A

EPA METHOD TO-3

(Aromatic Volatile Organics in Air)

GC/PID

File Name:	**6062315**		**Date of Collection: 6/11/95**	
Dil. Factor:	**70**		**Date of Analysis: 6/23/95**	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
Benzene	0.070	0.23	0.65	2.1
Toluene	0.070	0.27	0.36	1.4
Ethyl Benzene	0.070	0.31	2.2	9.7
Total Xylenes	0.070	0.31	2.3	10

TOTAL PETROLEUM HYDROCARBONS

GC/FID

(Quantitated as Jet Fuel)

File Name:	**6062315**		**Date of Collection: 6/11/95**	
Dil. Factor:	**70**		**Date of Analysis: 6/23/95**	
Compound	**Det. Limit (ppmv)**	**Det. Limit (uG/L)**	**Amount (ppmv)**	**Amount (uG/L)**
TPH* (C5+ Hydrocarbons)	0.70	4.5	1100	7100
C2 - C4** Hydrocarbons	0.70	1.3	Not Detected	Not Detected

*TPH referenced to Jet Fuel (MW=156)

**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: 1 Liter SUMMA Canister

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank

ID#: 9506185-03A

EPA METHOD TO-3

(Aromatic Volatile Organics in Air)

GC/PID

File Name: 6062313 | Date of Collection: NA

Dil. Factor: 1.0 | Date of Analysis: 6/23/95

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.001	0.003	Not Detected	Not Detected
Toluene	0.001	0.004	Not Detected	Not Detected
Ethyl Benzene	0.001	0.004	Not Detected	Not Detected
Total Xylenes	0.001	0.004	Not Detected	Not Detected

TOTAL PETROLEUM HYDROCARBONS

GC/FID

(Quantitated as Jet Fuel)

File Name: 6062313 | Date of Collection: NA

Dil. Factor: 1.0 | Date of Analysis: 6/23/95

Compound	Det. Limit (ppmv)	Det. Limit (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH* (C5+ Hydrocarbons)	0.010	0.065	Not Detected	Not Detected
C2 - C4** Hydrocarbons	0.010	0.018	Not Detected	Not Detected

*TPH referenced to Jet Fuel (MW=156)

**C2 - C4 Hydrocarbons referenced to Propane (MW=44)

Container Type: NA

Battelle
Columbus Laboratories

AIR TOXICS

9506185 -

CHAIN OF CUSTODY RECORD

Form No. 001

Proj. No.	Project Title
6462201	BIOSLURPER Johnston Atoll

SAMPLERS: (Signature) Headington / Woolfe

	DATE	TIME	SAMPLE I.D.	BTEX	TPH	Container No.	Number of Containers	Remarks
1A	10JUN95	1430	JA4-STK-1				1	#1062
2A	11JUN95	1205	JA4-STK-2				1	#0611

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Dury Headington	12JUN95 1030				

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)

Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks
		[signature] ATL	4/19/95 930	QUESTIONS AND DATA REPORT TO AL POLLACK, BATTELLE (614) 424-3753

Custody Seal intact? Y N None [redacted] Temp. Ambient [redacted] good [redacted] 1 [redacted] of [redacted] 1 [redacted]

pace INCORPORATED
ENVIRONMENTAL LABORATORIES

9608 Loiret Boulevard
Lenexa, KS 66219
TEL: 913-599-5665
FAX: 913-599-1759

Fax Transmittal Cover Sheet

Date: 7/21/95

To: ATN: Andrea Leeson

Fax #: 614 - 424 - 3667

Total Number of Pages (Including This Cover):

Sender: CHARLES GIRGIN Phone: (913) 599-5665

Comments: ATTACHED ARE THE HYDROCARBON EVALUATIONS BASED UPON TOTAL FID RESPONSE.

If you have questions regarding this fax transmission, please contact:

__________ Phone: __________

Response Requested? Yes _____ No _____

FORMFAX:15 12/94

pace INCORPORATED
ENVIRONMENTAL LABORATORIES

Hydrocarbon Range		% V. Total Response
< C10	—	2.80%
C10 – C12	—	11.53%
C12 – C14	—	19.89%
C14 – C16	—	32.58%
C16 – C18	—	24.41%
C18 – C20	—	5.43%
C20 – C22	—	2.37%
C22 – C24	—	0.74%
C24 – C26	—	0.05%
C26 – C28	—	0.22%
> C28	—	0.06%
		100.08%

9608 Loiret Boulevard
Lenexa, KS 66219
TEL: 913-599-5665
FAX: 913-599-1759

An Equal Opportunity Employer

Software Version: 3.3 <4B11>

Sample Name : 60356045
Sample Number:
Operator : EMA

Time : 7/21/95 13:17
Study : MOD8015/OA2

Instrument : KS101
AutoSampler : HP7673A
Rack/Vial : 1/19

Channel : A A/D mV Range : 1024

Interface Serial # : Data Acquisition Time: 6/21/95 12:39
Delay Time : 0.00 min.
End Time : 34.99 min.
Sampling Rate : 2.5000 pts/sec

Raw Data File : C:\2700\KS101\1AFK019.RAW
Result File : C:\2700\KS101\1AFK019C.RST
Instrument File: C:\2700\KS101\TPHH
Process File : C:\2700\KS101\1AFK.prc
Sample File : C:\2700\KS101\1AFK-T.smp
Sequence File : c:\2700\ks101\1afk.seq

Inj. Volume : 1 ul
Sample Amount : 0.2900

Area Reject : 250.000000
Dilution Factor : 1.00

Noise Threshold: 10
Multiplier : 0.1000

Area Threshold : 50
Divisor : 0.2900

Bunch Factor: 2
Adder : 0.0000

Instrument Conditions:
Capillary GC -
Instrument : KS101
Run log : 1619
Column A/B : HP-5(1528-12-17)
Column length : 30M X 0.53MM X 0.88uM
Carrier gas : HELIUM
Flow Rate : 8 PSI
Split Ratio : 4:1
Temperature : START 60 C, HOLD 6 MIN., 12 C/MIN. TO 300 C, HOLD 9 MIN.
Injection Temp.: 250 C
Detector 1 : 300 C
Notes :

Total Number of Peaks Detected: 160

TOTAL PETROLEUM HYDROCARBONS

PACE ENVIRONMENTAL LABORATORIES - KANSAS REGION

Peak #	Ret Time [min]	Component Name	Height [uV]	Area [uV*sec]	% C-Range
	4.870	<C10	8069	51043	0.0280
	9.610	C10	51190	210073	0.1153
	12.710	C12	107152	362386	0.1989
	14.960	C14	157471	593543	0.3258
	16.885	C16	155026	444720	0.2441
	18.250	TOTAL TPH RESPONSE	518607	1822024	1.0000
	18.520	C18	23956	98953	0.0543
	20.085	C20	11467	43267	0.0237
	21.610	C22	3121	13533	0.0074
	22.940	C24	266	913	0.0005

Result File : 1AFK019C.RST, Printed On 7/21/95 13:17

Peak #	Ret Time [min]	Component Name	Height [uV]	Area [uV*sec]	% C-Range
	24.175	C26	1250	3972	0.0022
	29.385	>C28	279	1183	0.0006
			1037855	3645609	2.0009

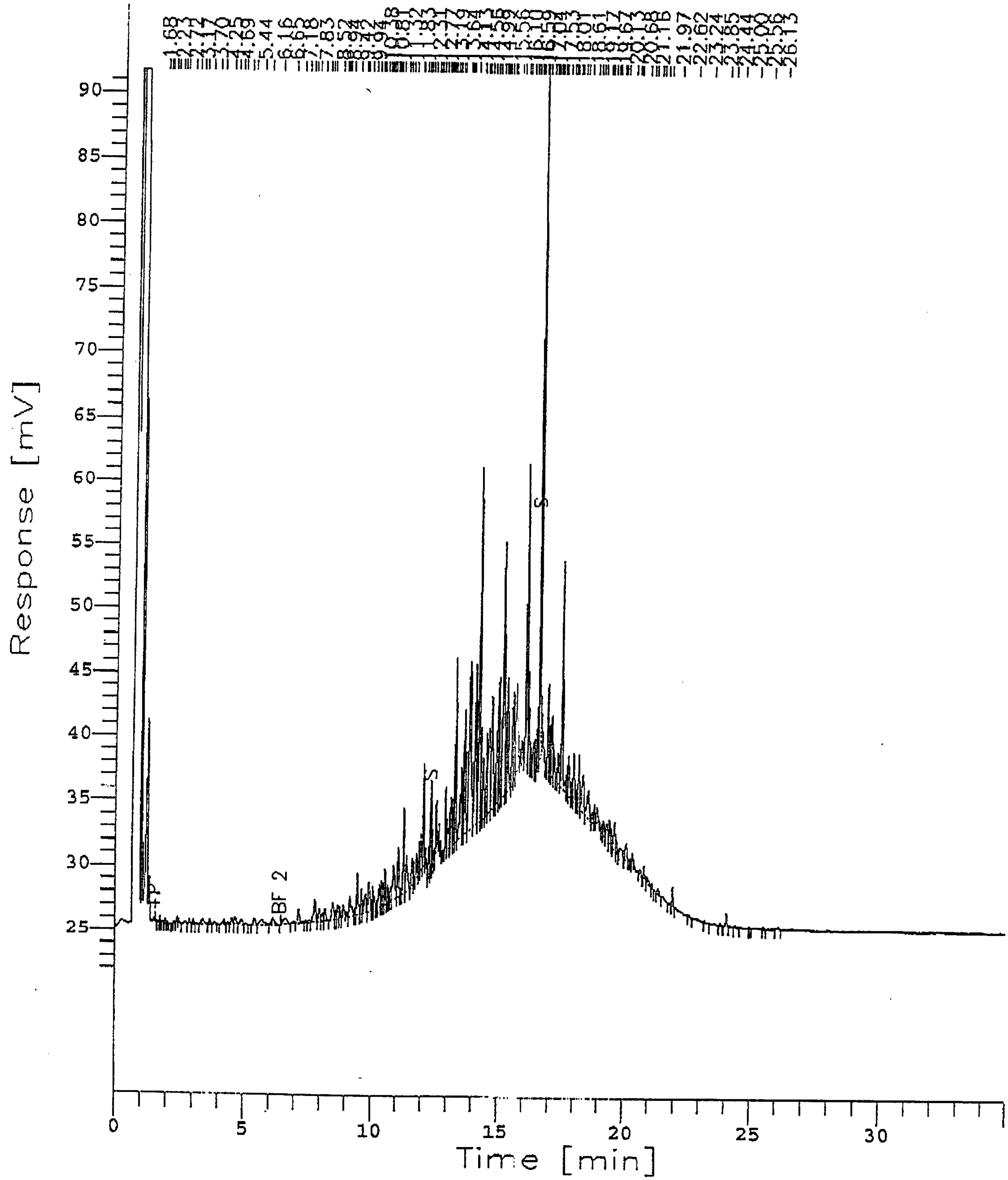
KS101; DB-5; 1uL INJ. VOLUME

Sample Name : 60356045
FileName : c:\2700\ks101\1AFK019.raw
Method : TPHH.ins
Start Time : 0.00 min
Scale Factor: -1.0

End Time : 34.99 min
Plot Offset: 22 mV

Sample #:
Date : 7/21/95 13:17
Time of Injection: 6/21/95 12:39
Low Point : 21.75 mV
Plot Scale: 70.0 mV

High Point : 91.75 mV



Software Version: 3.3 <4B11>
Sample Name : C10-C18 MIX
Sample Number: 1234/332
Operator : EMA

Time : 3/17/95 08:31
Study : MOD 8015 EXT. TPH

Instrument : KS101
AutoSampler : HP7673A
Rack/Vial : 1/16

Channel : A   A/D mV Range : 1024

Interface Serial # :   Data Acquisition Time: 3/10/95 02:24
Delay Time : 0.00 min.
End Time : 34.99 min.
Sampling Rate : 2.5000 pts/sec

Raw Data File : C:\2700\KS101\1AC9016.RAW
Result File : C:\2700\KS101\1AC9016.RST
Instrument File: C:\2700\KS101\TPHH
Process File : C:\2700\KS101\1AC9.prc
Sample File : C:\2700\KS101\1AC9.smp
Sequence File : c:\2700\ks101\1ac9.seq

Inj. Volume : 1 ul
Sample Amount : 1.0000

Area Reject : 250.000000
Dilution Factor : 1.00

Noise Threshold: 20
Multiplier : 1.0000

Area Threshold : 50
Divisor : 1.0000

Bunch Factor: 1
Adder : 0.0000

Instrument Conditions:
Capillary GC -
Instrument : KS101
Run log : 1619
Column A/B : HP-5(1528-12-17)
Column length : 30M X 0.53MM X 0.88uM
Carrier gas : HELIUM
Flow Rate : 8 PSI
Split Ratio : 4:1
Temperature : START 60 C, HOLD 6 MIN., 12 C/MIN. TO 300 C, HOLD 9 MIN.
Injection Temp.: 250 C
Detector 1 : 300 C
Notes :

Total Number of Peaks Detected: 44

TOTAL PETROLEUM HYDROCARBONS

PACE ENVIRONMENTAL LABORATORIES - KANSAS REGION

Peak #	Ret Time [min]	Component Name	Height [UV]	Area [UV*sec]	Raw Amount SOLN (mg/L)
	5.800	NAPTHA-3	669164	2758178	316.7
	7.315	MINERAL SPIRITS	1681645	5542759	1046.1
	8.860	JP4-AVIATION FUEL	3688825	11099884	3162.1
	9.095	GASOLINE	3685199	11094708	3790.7
	9.740	JP8-AVIATION FUEL	4702176	13971374	3104.5
	10.940	KEROSENE	3674353	11061069	2021.6
	11.484	HYDROCARBONS	4638863	13757575	13.8
	13.945	DIESEL FUEL No. 2	4688054	13933113	3613.6
	13.945	TPH-1 DIESEL No.2	4688054	13933113	3613.6
	14.845	#4 FUEL OIL	4688169	13933586	3585.0

Peak #	Ret Time [min]	Component Name	Height [uV]	Area [uV*sec]	Raw Amount SOLN (mg/L)
	18.200	MINERAL OIL-1	2018066	5663212	14761.6
	20.950	MINERAL OIL-3	2018066	5663212	11341.2
	21.485	MOTOR OIL-3 10W-40	3017351	8418959	19870.4
	22.520	MOTOR OIL-1 10W-40	2013754	5651689	13344.5
			45871739	136482431	83585.4

Group Report For : HYDROCARBONS

Peak #	Ret Time [min]	Component Name	Height [uV]	Area [uV*sec]	Raw Amount SOLN (mg/L)
15	7.740	C10	624289	2595155	0.6
22	11.484	C12	1009472	2776403	1.0
29	13.939	C14	999285	2755747	1.0
34	15.981	C16	999627	2778115	1.0
39	17.790	C18	1006118	2851961	1.0
44	19.253	C20	72	194	7.2407e-05
0	20.921	C22	0	0	0.0
0	22.298	N-TETRACOSANE(C24)	0	0	0.0
0	23.580	C26	0	0	0.0
0	24.770	C28	0	0	0.0
			4638863	13757575	4.6

Group Report For : SURROGATES

Peak #	Ret Time [min]	Component Name	Height [uV]	Area [uV*sec]	Raw Amount SOLN (mg/L)
0	22.298	N-TETRACOSANE(C24)	0	0	0.0
0	24.438	DI-N-OCTYL PHTHALATE	0	0	0.0
			0	0	0.0

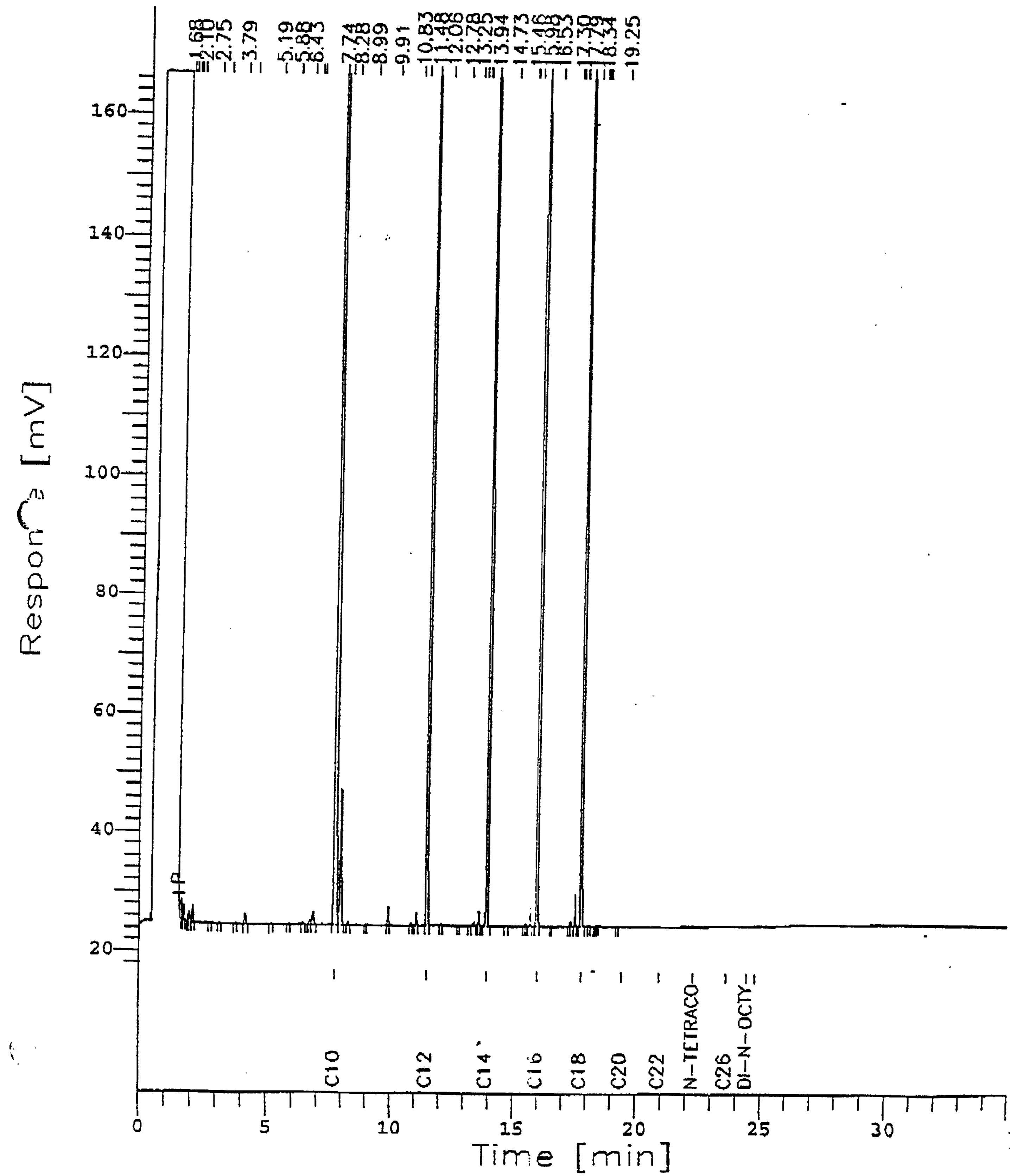
KS101; DB-5; 1uL INJ. VOLUME

Sample Name : C10-C18 MIX
FileName : C:\2700\KS101\1AC9016.raw
Method : TPHH
Start Time : 0.00 min
S...e Factor: -1.0

End Time : 34.99 min
Plot Offset: 17 mV

Sample #: 1234/332
Date : 3/17/95 08:31
Time of Injection: 3/10/95 02:24
Low Point : 17.07 mV
Plot Scale: 150.0 mV

High Point : 167.07 mV



Software Version: 3.3 <4B11>
Sample Name : C20-C28 MIX
Sample Number: 008-01-148
Operator : EMA

Time : 3/17/95 08:32
Study : MOD 8015 EXT. TPH

Instrument : KS101
AutoSampler : HP7673A
Rack/Vial : 1/18

Channel : A A/D mV Range : 1024

Interface Serial # : Data Acquisition Time: 3/10/95 03:47
Delay Time : 0.00 min.
End Time : 34.99 min.
Sampling Rate : 2.5000 pts/sec

Raw Data File : C:\2700\KS101\1AC9018.RAW
Result File : C:\2700\KS101\1AC9018.RST
Instrument File: C:\2700\KS101\TPHH
Process File : C:\2700\KS101\1AC9.prc
Sample File : C:\2700\KS101\1AC9.smp
Sequence File : c:\2700\ks101\1ac9.seq

Inj. Volume : 1 ul
Sample Amount : 1.0000

Area Reject : 250.000000
Dilution Factor : 1.00

Noise Threshold: 20
Multiplier : 1.0000

Area Threshold : 50
Divisor : 1.0000

Bunch Factor: 1
Adder : 0.0000

Instrument Conditions:
Capillary GC -
Instrument : KS101
Run log : 1619
Column A/B : HP-5(1528-12-17)
Column length : 30M X 0.53MM X 0.88uM
Carrier gas : HELIUM
Flow Rate : 8 PSI
Split Ratio : 4:1
Temperature : START 60 C, HOLD 6 MIN., 12 C/MIN. TO 300 C, HOLD 9 MIN.
Injection Temp.: 250 C
Detector 1 : 300 C
Notes :

Total Number of Peaks Detected: 17

TOTAL PETROLEUM HYDROCARBONS

PACE ENVIRONMENTAL LABORATORIES - KANSAS REGION

Peak #	Ret Time [min]	Component Name	Height [uV]	Area [uV*sec]	Raw Amount SOLN (mg/L)
	5.800	NAPTHA-3	8044	12070	3.8
	7.315	MINERAL SPIRITS	8044	12070	5.0
	8.860	JP4-AVIATION FUEL	8126	12343	7.0
	9.095	GASOLINE	8126	12343	8.4
	9.740	JP8-AVIATION FUEL	8126	12343	5.4
	10.940	KEROSENE	82	273	4.4940e-02
	13.945	DIESEL FUEL No. 2	172449	488341	132.9
	13.945	TPH-1 DIESEL No.2	172449	488341	132.9
	14.845	#4 FUEL OIL	395359	1162955	302.3
	18.200	MINERAL OIL-1	172449	488341	1261.4

Result File : 1AC9018.RST, Printed On 3/17/95 08:32

Peak #	Ret Time [min]	Component Name	Height [uV]	Area [uV*sec]	Raw Amount SOLN (mg/L)
	20.950	MINERAL OIL-3	473342	1410491	2660.1
	21.485	MOTOR OIL-3 10W-40	473342	1410491	3117.1
	22.301	SURROGATES	103983	308016	0.1
	22.520	MOTOR OIL-1 10W-40	473260	1410218	3136.1
	23.450	MINERAL OIL-2	118769	366013	2998.3
	23.450	TPH-2 DIESEL No.2	118769	366013	91.5
	23.450	MOTOR OIL-2 10W-40	118769	366013	2939.4
	23.580	HYDROCARBONS	470278	1401448	1.4
	27.585	TPH-3 DIESEL No 2	77900	247313	60.0
			3381664	9975435	16863.3

Group Report For : HYDROCARBONS

Peak #	Ret Time [min]	Component Name	Height [uV]	Area [uV*sec]	Raw Amount SOLN (mg/L)
0	7.740	C10	0	0	0.0
0	11.484	C12	0	0	0.0
0	13.939	C14	0	0	0.0
0	15.981	C16	0	0	0.0
0	17.790	C18	0	0	0.0
6	19.422	C20	88488	246305	8.8488e-02
9	20.921	C22	81616	235342	8.1616e-02
11	22.301	N-TETRACOSANE(C24)	103983	308016	27.7
13	23.580	C26	118544	365368	0.1
15	24.770	C28	77646	246417	7.7646e-02
			470278	1401448	28.1

Group Report For : SURROGATES

Peak #	Ret Time [min]	Component Name	Height [uV]	Area [uV*sec]	Raw Amount SOLN (mg/L)
11	22.301	N-TETRACOSANE(C24)	103983	308016	27.7
0	24.438	DI-N-OCTYL PHTHALATE	0	0	0.0
			103983	308016	27.7

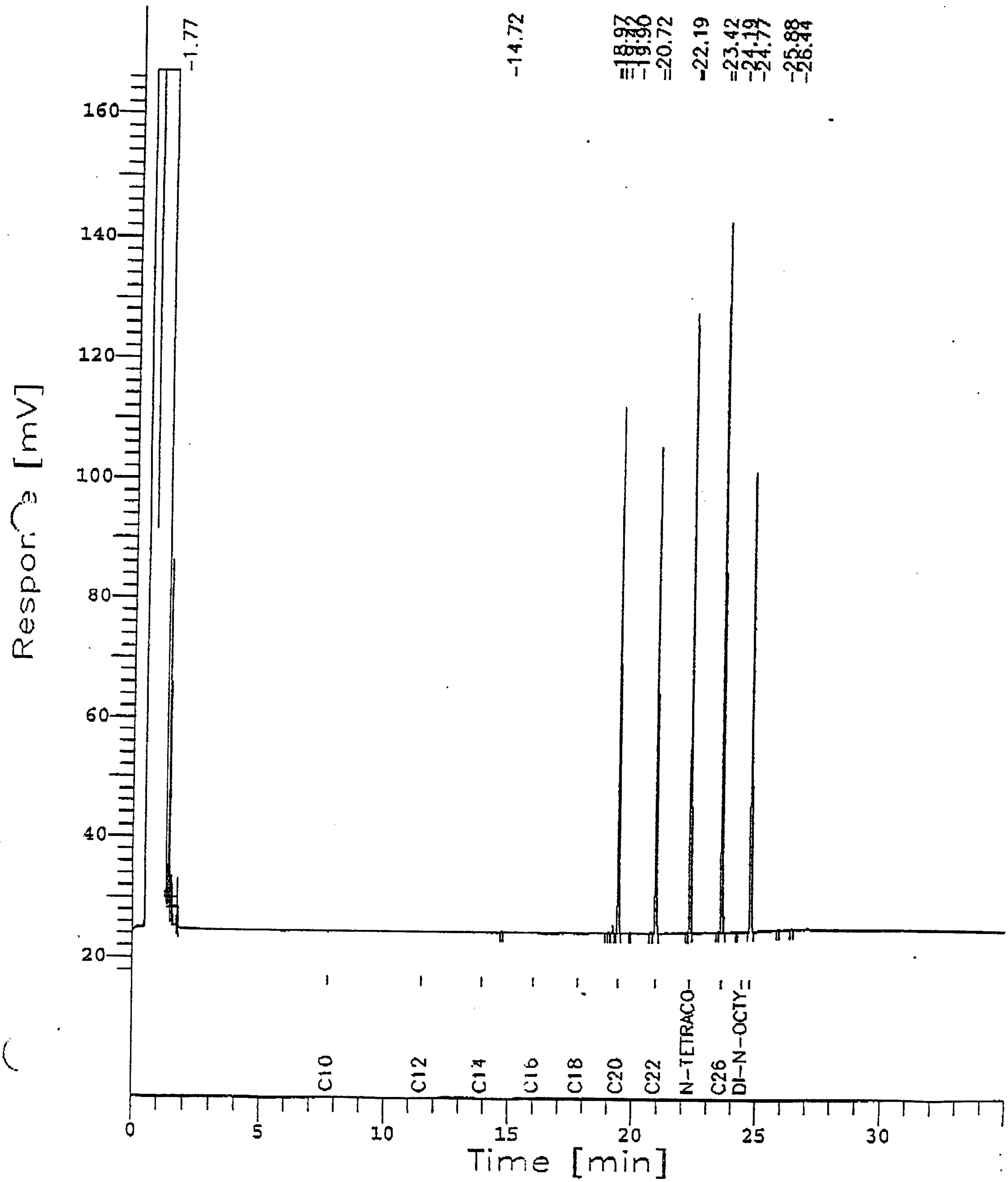
KS101; DB-5; 1uL INJ. VOLUME

Sample Name : C20-C28 MIX
FileName : C:\2700\KS101\1AC9018.raw
Method : TPHH
Start Time : 0.00 min
Scale Factor: -1.0

End Time : 34.99 min
Plot Offset: 17 mV

Sample #: 008-01-148
Date : 3/17/95 08:32
Time of Injection: 3/10/95 03:47
Low Point : 17.13 mV
Plot Scale: 150.0 mV

Page 1 of 1
High Point : 167.13 mV



E.L. Pacific
Environmental Laboratory of the Pacific

A Full Service Laboratory for the Environmental Professional
930 Mapunapuna Street, Suite 100 • Honolulu, Hawaii 96819
Telephone: (808) 831-3090 Facsimile: (808) 831-3098

Laboratory Report

Client: Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201
Attention: Al Pollack

ELP Project No.: 9506317
Report Date: 20-Jun-95

Client Job No.: G462201 Bioslurper
Client P.O. No.: 97867
Client Job Name: Johnston Atoll

Date Collected: see below
Date Received: 14-Jun-95

			Client ID:				JA4-EFF-1
			Date Collected:				09-Jun-95
			Matrix:				water
			Lab ID:		Method Blank		9506317-01
Date	**Analysis**	**Method**	**Units**	**MRL**	**Results**	**MRL**	**Results**
	BTEX in water						
15-Jun-95	Extraction	EPA 5030					
15-Jun-95	Benzene	EPA 8020	mg/L (ppm)	0.001	ND	0.005	ND
15-Jun-95	Toluene	EPA 8020	mg/L (ppm)	0.001	ND	0.005	ND
15-Jun-95	Ethylbenzene	EPA 8020	mg/L (ppm)	0.001	ND	0.005	**0.010**
15-Jun-95	Xylenes	EPA 8020	mg/L (ppm)	0.002	ND	0.010	ND
	Surrogate (% Recovery)						
15-Jun-95	Trifluorotoluene				**88**		**93**
	TPH in water						
15-Jun-95	Extraction	EPA 5030					
15-Jun-95	Gasoline	EPA 8015M	mg/L (ppm)	1	ND	5	ND

Comment: MRLs for samples 9506317-01 and 9506317-03 were raised due to dilution of the samples.

Approved by: Carl C. Bralts 6/20/95
Carl Bralts, Laboratory Manager

E.L. Pacific

ELP Project No.: 9506317
Report Date: 20-Jun-95

Client ID:	JA4-TB
Date Collected:	09-Jun-95
Matrix:	water
Lab ID:	Method Blank / 9506317-02

Date	Analysis	Method	Units	MRL	Results	MRL	Results
	BTEX in water						
15-Jun-95	Extraction	EPA 5030					
15-Jun-95	Benzene	EPA 8020	mg/L (ppm)	0.001	ND	0.001	ND
15-Jun-95	Toluene	EPA 8020	mg/L (ppm)	0.001	ND	0.001	ND
15-Jun-95	Ethylbenzene	EPA 8020	mg/L (ppm)	0.001	ND	0.001	ND
15-Jun-95	Xylenes	EPA 8020	mg/L (ppm)	0.002	ND	0.002	ND
	Surrogate (% Recovery)						
15-Jun-95	Trifluorotoluene				**88**		**93**
	TPH in water						
15-Jun-95	Extraction	EPA 5030					
15-Jun-95	Gasoline	EPA 8015	mg/L (ppm)	1	ND	1	ND

Client ID:	JA4-EFF-2
Date Collected:	11-Jun-95
Matrix:	water
Lab ID:	Method Blank / 9506317-03

Date	Analysis	Method	Units	MRL	Results	MRL	Results
	BTEX in water						
15-Jun-95	Extraction	EPA 5030					
15-Jun-95	Benzene	EPA 8020	mg/L (ppm)	0.001	ND	0.005	ND
15-Jun-95	Toluene	EPA 8020	mg/L (ppm)	0.001	ND	0.005	ND
15-Jun-95	Ethylbenzene	EPA 8020	mg/L (ppm)	0.001	ND	0.005	**0.007**
15-Jun-95	Xylenes	EPA 8020	mg/L (ppm)	0.002	ND	0.010	**ND**
	Surrogate (% Recovery)						
15-Jun-95	Trifluorotoluene				**88**		**93**
	TPH in water						
15-Jun-95	Extraction	EPA 5030					
15-Jun-95	Gasoline	EPA 8015	mg/L (ppm)	1	ND	5	ND

Approved by: Carl Bralts 6/20/95
Carl Bralts, Laboratory Manager

E.L. Pacific

ELP Project No.: 9506317
Report Date: 20-Jun-95

Quality Control Data

SPIKES		Lab ID:	LCS1	LCS2		MS	MSD	
		Units:	%R	%R	RPD	%R	%R	RPD
Lab ID	**Analysis**	**Method**	**Results**	**Results**	**Results**	**Results**	**Results**	**Results**
	BTEX in water							
9506323-01	Benzene	EPA 8020	105	106	1	111	110	1
9506323-01	Toluene	EPA 8020	106	105	1	111	109	2
9506323-01	Ethylbenzene	EPA 8020	102	102	0	106	103	3
9506323-01	Xylenes	EPA 8020	104	103	1	105	103	2
	Surrogate (% Recovery)							
9506323-01	Trifluorotoluene		97	105	8	101	101	0
	TPH in water							
9506323-01	Gasoline	EPA 8015M	105	94	11	89	*	*

* insufficient sample for matrix spike analysis

Approved by: Carl C Bralts 6/20/95
Carl Bralts, Laboratory Manager

E.L. Pacific

ELP Project No.: 9506317
Report Date: 20-Jun-95

Definitions

D	Duplicate
LCS	Laboratory Control Sample
MS	Matrix Spike
MSD	Matrix Spike Duplicate
MRL	Method Reporting Limit
NA	Not Applicable
ND	Not Detected at the MRL
NR	Not Requested
OS	Original Sample
%R	Percent Recovery
PDS	Post Digestion Spike
RPD	Relative Percent Difference

Approved by: Carl C Bralts 6/20/95
Carl Bralts, Laboratory Manager

1-HR 017 [illegible]

Battelle Columbus Laboratories

Memorial Institute
505 King Ave.
Columbus Ohio 43201

CHAIN OF CUSTODY RECORD

TO: EL PACIFIC / ATTN JOHN GRAVES

Form No. 001

PO# 97867

Proj. No. G462201 BIOSLURPER

Project Title: JOHNSTON ATOLL

SAMPLERS: (Signature) Headington / Woolfe

Remarks: WATER SAMPLES

DATE	TIME	SAMPLE I.D.	BTEX / TPH AS GASOLINE	SAMPLE TYPE (√)	Container No.	Number of Containers	Remarks
09JUN95	0720	JA4-Eff-1	X	95 06 317 -01		2	40 cc sep/a vial
09JUN95	0720	JA4-TB	X	-02		1	40cc vial
11JUN95	1630	JA4-Eff-2	X	-03		2	40 cc vial

ELP #: 9506317
Lab d/d: 6/26/95
Rpt. d/d: 6/28/95
Location/Container: voa/#6

Relinquished by: (Signature)	Date/Time		Received by: (Signature)	Relinquished by: (Signature)	Date/Time		Received by: (Signature)
Headington	12JUN95	1030	Mike Shotton	Mike Shotton	6-13-95	8:30	Eric Jackson
Relinquished by: (Signature)	Date/Time		Received by: 6/14/95 P.C.P. (Signature) Eleanor Elcoton	Relinquished by: (Signature)	Date/Time		Received by: (Signature)
Relinquished by: (Signature)	Date/Time		Received for Laboratory by: (Signature)	Date/Time		Remarks	QUESTIONS AND DATA REPORT TO AL POLLACK, BATTELLE

[redacted] ([redacted]) 4[redacted] 3[redacted]3 [redacted] [redacted] of [redacted] [redacted]

PACE INCORPORATED
ENVIRONMENTAL LABORATORIES

July 14, 1995

Brian
C
Post

Allan Pollack
Battelle
505 King Avenue
Columbus, OH 43201-2693

Charles Gunger
(913) 599-5665
Kansas Region
Lab.
He did the fuel
analysis.
Talked to him
7-21-95

Re: PACE Project No.: CL 2447
Client Reference: Bioventing/Bioslurping

Dear Mr. Pollack:

Enclosed is a report of laboratory analysis for the above referenced project. Samples were received under chain-of-custody at the Pace on 06/08/95.

BTEX and TPH (diesel) were analyzed at the Pace-Kansas facility. Seive analysis, bulk density and porosity were sub-contracted to Environmental Geotechnology.

Also enclosed are the chromatograms for Client Sample ID " JA4-Fuel".

This report has been reviewed for accuracy and completeness and conforms to your analytical requirements.

If you have any questions regarding this report, require sampling supplies, field services or information on our analytical services, please call me at (805) 389-1353.

Sincerely,

Melanie C. Gonzalez

Melanie Concepcion-Gonzalez
Project Manager, PACE Southern California

Enclosures

17150 Newhope Street, Suite 502
Fountain Valley, CA 92708
TEL: 714-437-1959
FAX: 714-437-1462

ENVIRONMENTAL LABORATORIES

REPORT OF LABORATORY ANALYSIS

June 29, 1995

Project Manager
Orange County Service Center
PACE, Incorporated
17150 Newhope St. Suite 502
Fountain Valley, CA 92708

RE: PACE Project Number: 605115
Client Project ID: Biovent CL2447

Dear :

Enclosed are the results of analyses for samples received on June 9, 1995. If you have any questions concerning this report, please feel free to contact me.

Sincerely,

DeWayne McAllister
Project Manager

Enclosures

pace INCORPORATED
ENVIRONMENTAL LABORATORIES

REPORT OF LABORATORY ANALYSIS

PACE Project Number: 605115
Client Project ID: Biovent CL2447

PACE Sample No: 60356011 Date Collected: 06/06/95
Client Sample ID: JA4 5.0-5.5 Date Received: 06/09/95

Parameters	Results	Units	PRL	Analyzed	Method	Analyst	CAS#	Footnotes
GC -- Volatiles								
Aromatic Volatile Organics								
Benzene	ND	ug/kg	50	06/19/95	EPA 8020	TAT	71-43-2	
Ethyl Benzene	240	ug/kg	50	06/19/95	EPA 8020	TAT	100-41-4	
Toluene	ND	ug/kg	50	06/19/95	EPA 8020	TAT	108-88-3	
Xylene (Total)	300	ug/kg	130	06/19/95	EPA 8020	TAT	1330-20-7	
a,a,a-Trifluorotoluene (S)	80	%		06/19/95	EPA 8020	TAT	2164-17-2	
GC								
TPH, Soil, Ext. by Mod. 8015								
Mineral Spirits	ND	mg/kg	83	06/22/95	EPA Mod 8015 ext	EMA		
Gasoline	ND	mg/kg	83	06/22/95	EPA Mod 8015 ext	EMA		
Jet Fuel	ND	mg/kg	83	06/22/95	EPA Mod 8015 ext	EMA		
Kerosene	ND	mg/kg	83	06/22/95	EPA Mod 8015 ext	EMA		
Diesel Fuel	6400	mg/kg	83	06/22/95	EPA Mod 8015 ext	EMA		
Fuel Oil	ND	mg/kg	83	06/22/95	EPA Mod 8015 ext	EMA		
Motor Oil	ND	mg/kg	83	06/22/95	EPA Mod 8015 ext	EMA		
Di-n-octylphthalate (S)	0	%		06/22/95	EPA Mod 8015 ext	EMA	117-84-0	2
n-Tetracosane (S)	0	%		06/22/95	EPA Mod 8015 ext	EMA	646-31-1	2
Date Extracted				06/13/95				

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ENVIRONMENTAL LABORATORIES

REPORT OF LABORATORY ANALYSIS

PACE Project Number: 605115
Client Project ID: Biovent CL2447

PACE Sample No: 60356029 Date Collected: 06/06/95
Client Sample ID: JA4 5.5-6.0 Date Received: 06/09/95

Parameters	Results	Units	PRL	Analyzed	Method	Analyst	CAS#	Footnotes
GC -- Volatiles								
Aromatic Volatile Organics								
Benzene	ND	ug/kg	50	06/19/95	EPA 8020	TAT	71-43-2	
Ethyl Benzene	720	ug/kg	50	06/19/95	EPA 8020	TAT	100-41-4	
Toluene	ND	ug/kg	50	06/19/95	EPA 8020	TAT	108-88-3	
Xylene (Total)	510	ug/kg	130	06/19/95	EPA 8020	TAT	1330-20-7	
a,a,a-Trifluorotoluene (S)	71	%		06/19/95	EPA 8020	TAT	2164-17-2	
GC								
TPH, Soil, Ext. by Mod. 8015								
Mineral Spirits	ND	mg/kg	330	06/22/95	EPA Mod 8015 ext	EMA		
Gasoline	ND	mg/kg	330	06/22/95	EPA Mod 8015 ext	EMA		
Jet Fuel	ND	mg/kg	330	06/22/95	EPA Mod 8015 ext	EMA		
Kerosene	ND	mg/kg	330	06/22/95	EPA Mod 8015 ext	EMA		
Diesel Fuel	23000	mg/kg	330	06/22/95	EPA Mod 8015 ext	EMA		
Fuel Oil	ND	mg/kg	330	06/22/95	EPA Mod 8015 ext	EMA		
Motor Oil	ND	mg/kg	330	06/22/95	EPA Mod 8015 ext	EMA		
Di-n-octylphthalate (S)	0	%		06/22/95	EPA Mod 8015 ext	EMA	117-84-0	2
n-Tetracosane (S)	0	%		06/22/95	EPA Mod 8015 ext	EMA	646-31-1	2
Date Extracted				06/13/95				

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PACE INCORPORATED
ENVIRONMENTAL LABORATORIES

REPORT OF LABORATORY ANALYSIS

DATE: 06/29/95

PACE Project Number: 605115
Client Project ID: Biovent CL2447

PACE Sample No: 60356037 Date Collected: 06/06/95
Client Sample ID: JA4 7.0-7.5 Date Received: 06/09/95

Parameters	Results	Units	PRL	Analyzed	Method	Analyst	CAS#	Footnotes
GC -- Volatiles								
Aromatic Volatile Organics								
Benzene	ND	ug/kg	50	06/20/95	EPA 8020	TAT	71-43-2	
Ethyl Benzene	490	ug/kg	50	06/20/95	EPA 8020	TAT	100-41-4	
Toluene	ND	ug/kg	50	06/20/95	EPA 8020	TAT	108-88-3	
Xylene (Total)	380	ug/kg	130	06/20/95	EPA 8020	TAT	1330-20-7	
a,a,a-Trifluorotoluene (S)	62	%		06/20/95	EPA 8020	TAT	2164-17-2	
GC								
TPH, Soil, Ext. by Mod. 8015								
Mineral Spirits	ND	mg/kg	330	06/22/95	EPA Mod 8015 ext	EMA		
Gasoline	ND	mg/kg	330	06/22/95	EPA Mod 8015 ext	EMA		
Jet Fuel	ND	mg/kg	330	06/22/95	EPA Mod 8015 ext	EMA		
Kerosene	ND	mg/kg	330	06/22/95	EPA Mod 8015 ext	EMA		
Diesel Fuel	26000	mg/kg	330	06/22/95	EPA Mod 8015 ext	EMA		
Fuel Oil	ND	mg/kg	330	06/22/95	EPA Mod 8015 ext	EMA		
Motor Oil	ND	mg/kg	330	06/22/95	EPA Mod 8015 ext	EMA		
Di-n-octylphthalate (S)	0	%		06/22/95	EPA Mod 8015 ext	EMA	117-84-0	2
n-Tetracosane (S)	0	%		06/22/95	EPA Mod 8015 ext	EMA	646-31-1	2
Date Extracted				06/13/95				

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ENVIRONMENTAL LABORATORIES

REPORT OF LABORATORY ANALYSIS

PACE Project Number: 605115
Client Project ID: Biovent CL2447

PACE Sample No: 60356045 Date Collected: 06/06/95
Client Sample ID: JA4-FUEL Date Received: 06/09/95

Parameters	Results	Units	PRL	Analyzed	Method	Analyst	CAS#	Footnotes
GC -- Volatiles								
Aromatic Volatile Organics								
Benzene	ND	ug/kg	100	06/28/95	EPA 8020	HMF	71-43-2	
Ethyl Benzene	1800	ug/kg	100	06/28/95	EPA 8020	HMF	100-41-4	
Toluene	100	ug/kg	100	06/28/95	EPA 8020	HMF	108-88-3	
Xylene (Total)	640	ug/kg	250	06/28/95	EPA 8020	HMF	1330-20-7	
a,a,a-Trifluorotoluene (S)	20	%		06/28/95	EPA 8020	HMF	2164-17-2	3
GC								
TPH, Soil, Ext. by Mod. 8015								
Mineral Spirits	ND	mg/kg	6900	06/21/95	EPA Mod 8015 ext	EMA		
Gasoline	ND	mg/kg	6900	06/21/95	EPA Mod 8015 ext	EMA		
Jet Fuel	ND	mg/kg	6900	06/21/95	EPA Mod 8015 ext	EMA		
Kerosene	ND	mg/kg	6900	06/21/95	EPA Mod 8015 ext	EMA		
Diesel Fuel	580000	mg/kg	6900	06/21/95	EPA Mod 8015 ext	EMA		4
Fuel Oil	ND	mg/kg	6900	06/21/95	EPA Mod 8015 ext	EMA		
Motor Oil	ND	mg/kg	6900	06/21/95	EPA Mod 8015 ext	EMA		
Date Extracted				06/15/95				

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PACE INCORPORATED
ENVIRONMENTAL LABORATORIES

REPORT OF LABORATORY ANALYSIS

DATE: 06/29/95

PACE Project Number: 605115
Client Project ID: Biovent CL2447

PARAMETER FOOTNOTES

ND	Not Detected
NC	Not Calculable
PRL	PACE Reporting Limit
(S)	Surrogate
[1]	Surrogate recovery value for Di-n-Octyl Phthalate exceeds the established Laboratory Control Limit; however,the value for N-Tetracosane is within acceptable limit, therefore, the data is accepted.
[2]	The sample contains a high concentration analyte requiring sample dilution. The method detection limits are adjusted for the dilution and the surrogate recovery information is not available.
[3]	Surrogate recovery was low due to coelution. Reanalysis was done and resulsts duplicated. Therefore, results were accepted.
[4]	Quantitation of the Total Petroleum Hydrocarbon fraction was achieved using No. 2 diesel fuel as a reference standard.

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ENVIRONMENTAL LABORATORIES

REPORT OF LABORATORY ANALYSIS

QUALITY CONTROL DATA

PACE Project Number: 605115
Client Project ID: Biovent CL2447

Orange County Service Center
PACE, Incorporated
17150 Newhope St. Suite 502
Fountain Valley, CA 92708

Attn: Project Manager
Phone: (714)4371959

Date of Batch: 06/13/95

QC Batch ID: 8958
QC Batch Method: OA2

Associated PACE Samples: 60355955 60355963 60355971 60355989 60355997 60356003 60356011 60356029 60356037

METHOD BLANK: 60356276
Associated PACE Samples: 60355955 60355963 60355971 60355989 60355997 60356003 60356011 60356029 60356037

Parameter	Units	Method Blank Result	PRL	Footnotes
Mineral Spirits	mg/kg	ND	3.3	
Gasoline	mg/kg	ND	3.3	
Jet Fuel	mg/kg	ND	3.3	
Kerosene	mg/kg	ND	3.3	
Diesel Fuel	mg/kg	ND	3.3	
Fuel Oil	mg/kg	ND	3.3	
Motor Oil	mg/kg	ND	3.3	
Total Petroleum Hydrocarbons	mg/kg	ND	3.3	
Di-n-octylphthalate (S)	%	111		
n-Tetracosane (S)	%	107		

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 60356284 60356292

Parameter	Units	60355963	Spike Conc.	Matrix Spike Result	Spike % Rec	Matrix Sp. Dup. Result	Spike Dup % Rec	RPD	Footnotes
Diesel Fuel	mg/kg	ND	17	11	69	19	112	48	
Di-n-octylphthalate (S)					108		137		1
n-Tetracosane (S)					101		127		

PACE INCORPORATED
ENVIRONMENTAL LABORATORIES

REPORT OF LABORATORY ANALYSIS

QUALITY CONTROL DATA

PACE Project Number: 605115
Client Project ID: Biovent CL2447

LABORATORY CONTROL SAMPLE: 60356300

Parameter	Units	Spike Conc.	LCS Result	Spike % Rec	Footnotes
Diesel Fuel	mg/kg	17	17	102	
Di-n-octylphthalate (S)				114	
n-Tetracosane (S)				104	

REPORT OF LABORATORY ANALYSIS

QUALITY CONTROL DATA

PACE Project Number: 605115
Client Project ID: Biovent CL2447

Orange County Service Center
PACE, Incorporated
17150 Newhope St. Suite 502
Fountain Valley, CA 92708

Attn: Project Manager
Phone: (714)4371959

QC Batch ID: 9053
QC Batch Method: OA2
Date of Batch: 06/15/95
Associated PACE Samples: 60356045

METHOD BLANK: 60358926
Associated PACE Samples:
60356045

Parameter	Units	Method Blank Result	PRL	Footnotes
Mineral Spirits	mg/kg	ND	100	
Gasoline	mg/kg	ND	100	
Jet Fuel	mg/kg	ND	100	
Kerosene	mg/kg	ND	100	
Diesel Fuel	mg/kg	ND	100	
Fuel Oil	mg/kg	ND	100	
Motor Oil	mg/kg	ND	100	

LABORATORY CONTROL SAMPLE & LCSD: 60358934 60358942

Parameter	Units	Spike Conc.	LCS Result	Spike % Rec	LCSD Result	Spike Dup % Rec	RPD	Footnotes
Diesel Fuel	mg/kg	500	560	113	590	117	3	

PACE INCORPORATED
ENVIRONMENTAL LABORATORIES

REPORT OF LABORATORY ANALYSIS

QUALITY CONTROL DATA

Orange County Service Center
PACE, Incorporated
17150 Newhope St. Suite 502
Fountain Valley, CA 92708

PACE Project Number: 605115
Client Project ID: Biovent CL2447

Attn: Project Manager
Phone: (714)4371959

QC Batch ID: 9187
QC Batch Method: 5030 Med Lvl Soil
Date of Batch: 06/20/95

Associated PACE Samples: 60355955 60355963 60355971 60355989 60355997 60356003 60356011 60356029 60356037 60356045

METHOD BLANK: 60364148
Associated PACE Samples: 60355955 60355963 60355971 60355989 60355997 60356003 60356011 60356029 60356037 60356045

Parameter	Units	Method Blank Result	PRL	Footnotes
Benzene	ug/kg	ND	50	
Ethyl Benzene	ug/kg	ND	50	
Toluene	ug/kg	ND	50	
Xylene (Total)	ug/kg	ND	130	
a,a,a-Trifluorotoluene (S)	%	120		

MATRIX SPIKE & MATRIX SPIKE DUPLICATE: 60364163 60364171

Parameter	Units	60355955	Spike Conc.	Matrix Spike Result	Spike % Rec	Matrix Sp. Dup. Result	Spike Dup % Rec	RPD	Footnotes
Benzene	ug/kg	ND	500	500	101	510	103	2	
Ethyl Benzene	ug/kg	ND	500	470	93	470	96	3	
Toluene	ug/kg	ND	500	540	108	530	107	1	
Xylene (Total)	ug/kg	ND	1500	1400	94	1400	96	2	
a,a,a-Trifluorotoluene (S)					116		118		

LABORATORY CONTROL SAMPLE: 60364155

Parameter	Units	Spike Conc.	LCS Result	Spike % Rec	Footnotes
Benzene	ug/kg	500	490	98	
Ethyl Benzene	ug/kg	500	440	89	

PACE Project Number: 605115
Client Project ID: Biovent CL2447

LABORATORY CONTROL SAMPLE: 60364155

Parameter	Units	Spike Conc.	LCS Result	Spike % Rec	Footnotes
Toluene	ug/kg	500	480	95	
Xylene (Total)	ug/kg	1500	1300	88	
a,a,a-Trifluorotoluene (S)				130	

PACE INCORPORATED
ENVIRONMENTAL LABORATORIES

REPORT OF LABORATORY ANALYSIS

PACE Project Number: 605115
Client Project ID: Biovent CL2447

QUALITY CONTROL DATA PARAMETER FOOTNOTES

The Quality Control Sample Final Results listed above have been rounded to reflect an appropriate number of significant figures. Consistent with EPA guidelines unrounded concentrations have been used to calculate % Rec and RPD values.

ND	Not Detected
NC	Not Calculable
PRL	PACE Reporting Limit
RPD	Relative Percent Difference
(S)	Surrogate
[1]	Surrogate recovery value for Di-N-Octyl Phthalate exceeds the established Laboratory Control Limits, however, surrogate value for N-Tetracosane is within acceptable limits; therefore, the data is accepted.

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Environmental
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Laboratory

June 23, 1995

PACE Incorporated
17150 Newhope Street, Suite 502
Fountain Valley, CA 92708

Attention: Ms. Melanie Gonzalez

Subject: Report/Laboratory Testing Results
Project Name: Bioventing
Project No.: CL 2447
EGL Project No.: 95-064-001

Dear Ms. Gonzalez:

Enclosed are results of the laboratory testing program conducted on samples from the Bioventing project. The testing performed for this program was conducted in general accordance with testing procedures as follows:

TYPE OF TEST	TEST PROCEDURE
Moisture Content & Density	ASTM D2937
Sieve Analysis	ASTM D422
Specific Gravity	ASTM D854

Attached herewith are Summary of Index Properties Test Results ans Grain Size Distribution Curves.

We appreciate the opportunity to provide testing services to PACE Incorporated. If you have any questions regarding the test results, please contact us.

Very truly yours,

Environmental Geotechnology Laboratory (EGL)

S Sayawat

Somboon Sayawat
Lab Manager

Attachments

11823 Slauson Avenue, Unit 18, Santa Fe Springs, CA 90670 • Tel.: (310) 945-0689, Fax: (310) 945-0364

Environmental
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SUMMARY OF INDEX PROPERTIES TEST RESULTS

PROJECT NAME: BIOVENTING

EGL NO. : 95-0064-001

PROJECT NO: CL 2447

CLENT: PACE INCORPORATED

DATE: 6-23-95

SUMMARIZED BY: M. TAN

SAMPLE ID	DEPTH (FT)	MOISTURE CONTENT ASTM D2216 (%)	DRY DENSITY ASTM D2937 (PCF)	SPECIFIC GRAVITY ASTM D854	TOTAL POROSITY (%)	GRAIN SIZE DIST. ASTM D422 *(GR:SA:FI)
JA4	4.5-6.0	17.1	85.0	2.67	49.0	19:62:19
JA4	6.0-7.5	17.0	86.0	2.67	48.4	25:56:19

* GR:SA:FI = GRAVEL:SAND:FINES

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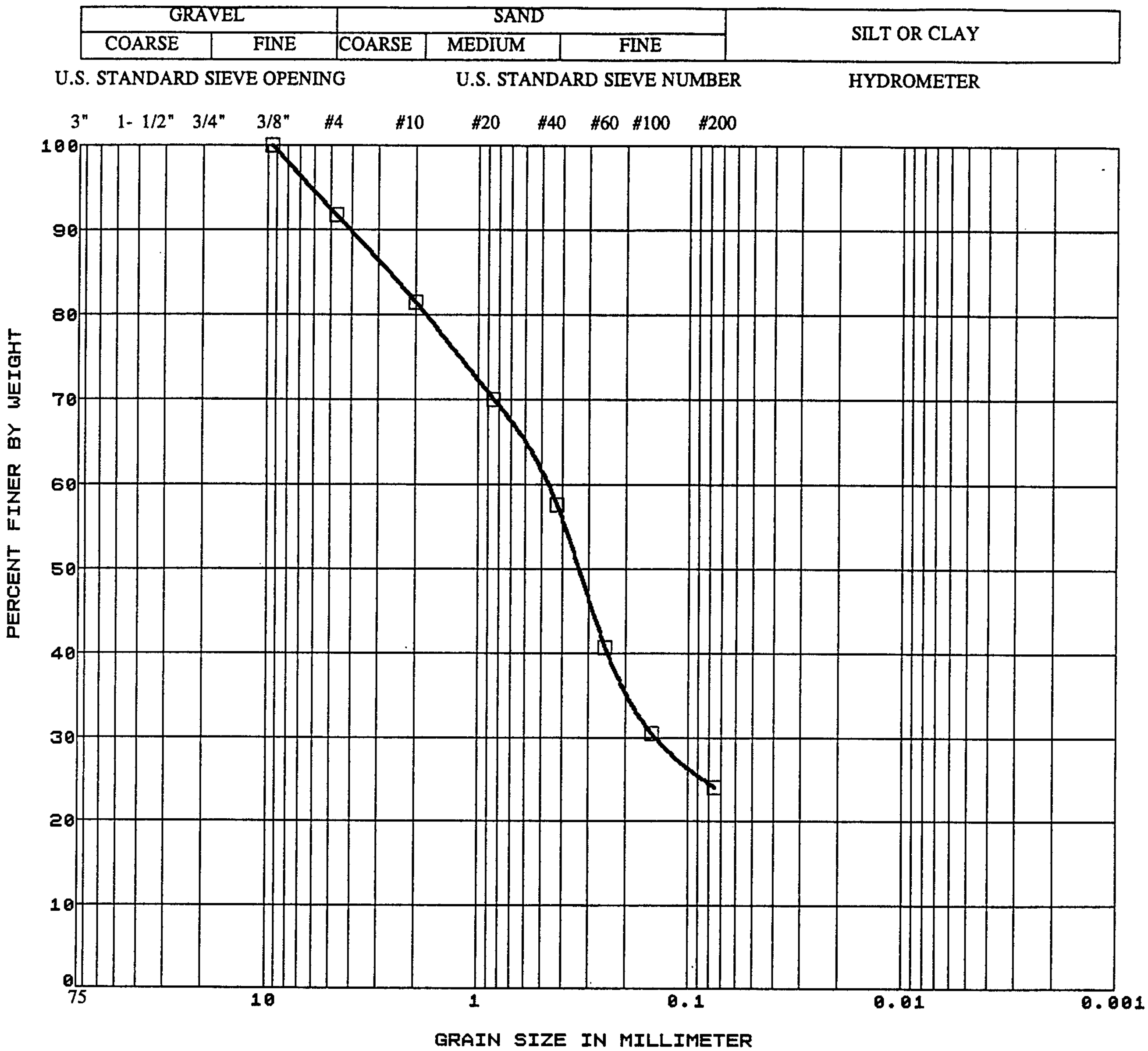


SYMBOL	SAMPLE ID.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
□	JA4	4.5-6.0	JAR			

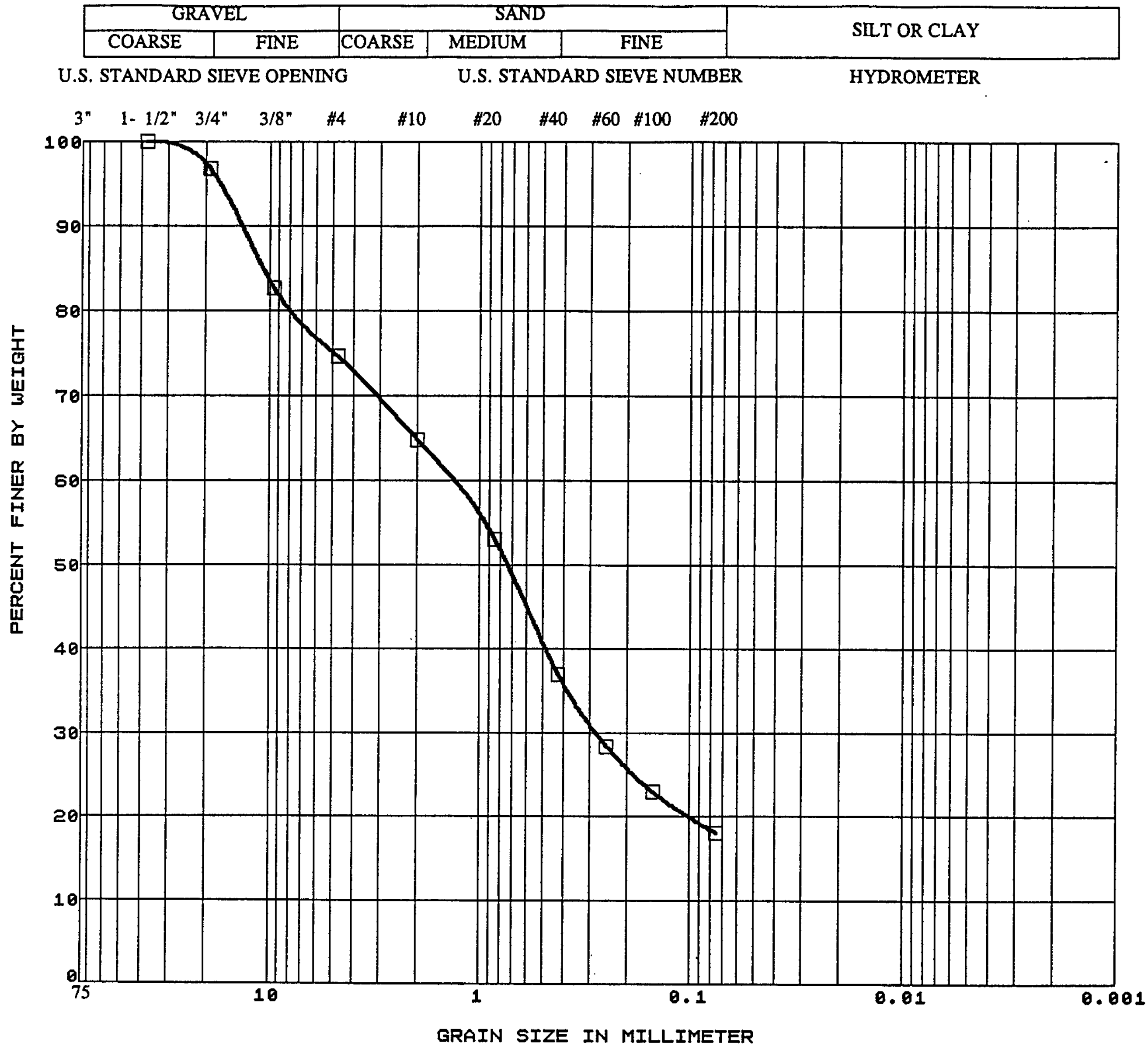
Environmental Geotechnology Laboratory

PROJECT NAME: BIOVENTING

GRAIN SIZE DISTRIBUTION CURVE

6/95

FIGURE



SYMBOL	SAMPLE ID.	DEPTH (FT)	SAMPLE TYPE	SOIL TYPE	LIQUID LIMIT	PLASTI-CITY INDEX
□	JA4	6.0-7.5	JAR			

Environmental Geotechnology Laboratory

PROJECT NAME: BIOVENTING

GRAIN SIZE DISTRIBUTION CURVE

6/95

FIGURE

===
Software Version: 3.3 <4B11>
Sample Name : 60356045 Time : 6/23/95 10:04
Sample Number: Study : MOD8015/OA2
Operator : EMA

Instrument : KS101 Channel : A A/D mV Range : 1024
AutoSampler : HP7673A
Rack/Vial : 1/19

Interface Serial # : Data Acquisition Time: 6/21/95 12:39
Delay Time : 0.00 min.
End Time : 34.99 min.
Sampling Rate : 2.5000 pts/sec

Raw Data File : C:\2700\KS101\1AFK019.RAW
Result File : C:\2700\KS101\1AFK019.RST
Instrument File: C:\2700\KS101\TPHH
Process File : C:\2700\KS101\1AFK.prc
Sample File : C:\2700\KS101\1AFK.smp
Sequence File : c:\2700\ks101\1afk.seq

Inj. Volume : 1 ul Area Reject : 250.000000
Sample Amount : 1.0000 Dilution Factor : 1.00

Noise Threshold: 10 Area Threshold : 50 Bunch Factor: 2
Multiplier : 100.0000 Divisor : 0.2900 Adder : 0.0000

Instrument Conditions:
Capillary GC -
Instrument : KS101
Run log : 1619
Column A/B : HP-5(1528-12-17)
Column length : 30M X 0.53MM X 0.88uM
Carrier gas : HELIUM
Flow Rate : 8 PSI
Split Ratio : 4:1
Temperature : START 60 C, HOLD 6 MIN., 12 C/MIN. TO 300 C, HOLD 9 MIN.
Injection Temp.: 250 C
Detector 1 : 300 C
Notes :

Total Number of Peaks Detected: 160
===

TOTAL PETROLEUM HYDROCARBONS

===
PACE ENVIRONMENTAL LABORATORIES - KANSAS REGION
===

Peak #	Ret Time [min]	Component Name	Height [uV]	Area [uV*sec]	Raw Amount SOLN (mg/L)	Sample Amount (mg/kg)
	8.560	MINERAL SPIRITS	250554	954520	782.9	782.9
	9.630	JP4-AVIATION FUEL	458739	1595857	2345.3	2345.3
	10.000	GASOLINE	489088	1699537	2527.2	2527.2
	10.225	JP8-AVIATION FUEL	498204	1746567	1003.0	1003.0
	10.835	KEROSENE	511397	1792003	1570.1	1570.1
	12.160	DIESEL FUEL No. 4	515309	1811250	1267.9	1267.9
	12.555	FUEL OIL No. 6-3	514204	1806286	3224.8	3224.8
	12.915	DIESEL FUEL No. 2	513290	1800503	1693.1	1693.1
	12.915	TPH-1 DIESEL No.2	513290	1800503	1693.1	1693.1
	18.490	MOTOR OIL-3 10W-40	249278	816016	9699.3	9699.3

Result File : 1AFK019.RST, Printed On 6/23/95 10:04

Peak #	Ret Time [min]	Component Name	Height [uV]	Area [uV*sec]	Raw Amount SOLN (mg/L)	Sample Amount (mg/kg)
	21.965	SURROGATES	2504	7841	2504.2	2504.2
	23.000	MOTOR OIL-2 10W-40	399	1418	32.6	32.6
	23.000	FUEL OIL#6-2	399	1418	80.0	80.0
	23.050	TPH-2 DIESEL No.2	399	1418	1.3	1.3
	27.050	MOTOR OIL-1 10W-40	395	1515	55.2	55.2
	27.050	FUEL OIL#6-1	395	1515	89.7	89.7
	27.050	TPH-3 DIESEL No 2	395	1515	1.3	1.3
			4518242	15839682	28571.1	28571.1

Group Report For : SURROGATES

Peak #	Ret Time [min]	Component Name	Height [uV]	Area [uV*sec]	Raw Amount SOLN (mg/L)	Sample Amount (mg/kg)
152	21.965	N-TETRACOSANE(C24)	1503	4706	1.6	1.6
156	24.094	DI-N-OCTYL PHTHALATE	1001	3135	1.7	1.7
			2504	7841	3.3	3.3

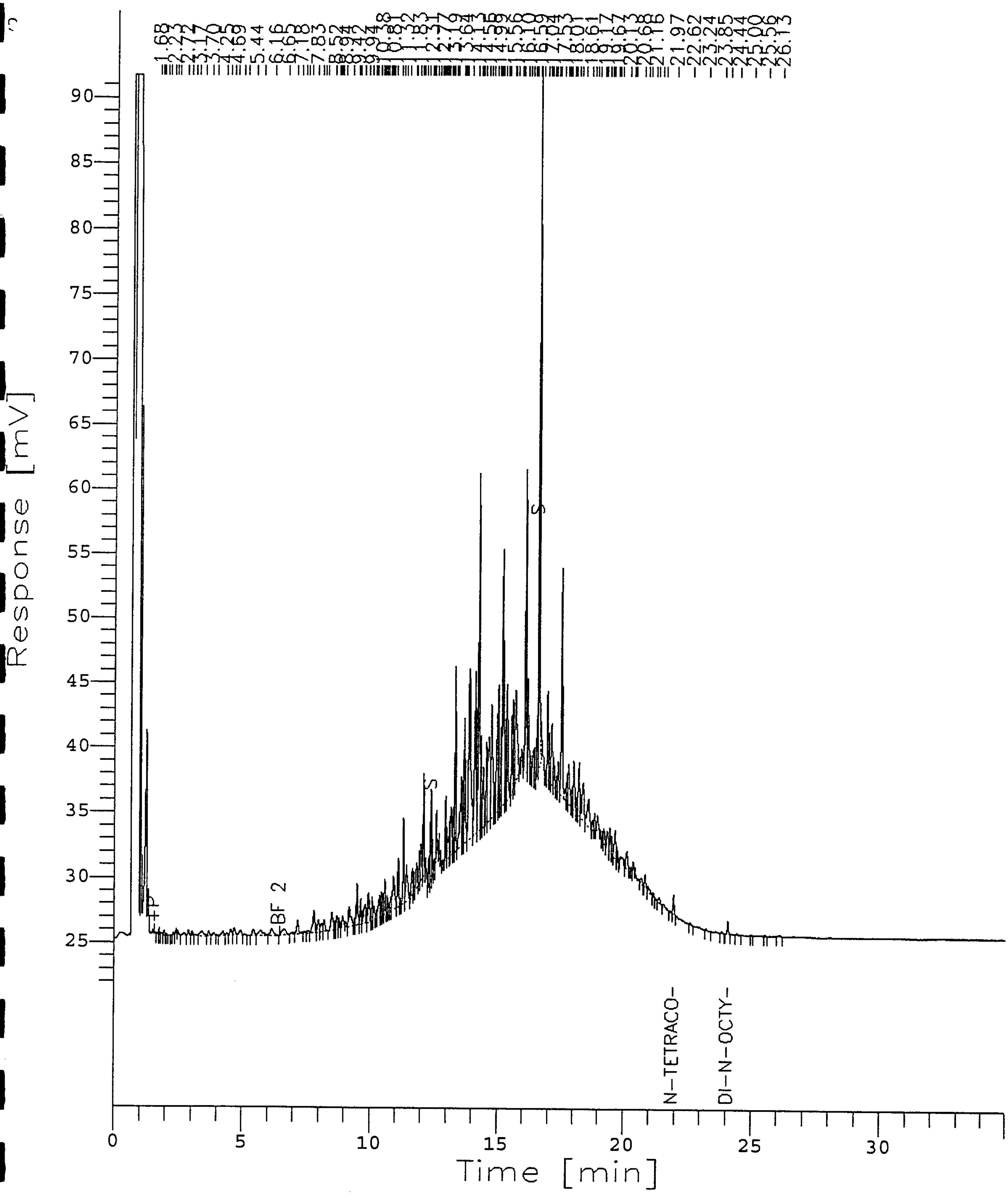
KS101; DB-5; 1uL INJ. VOLUME

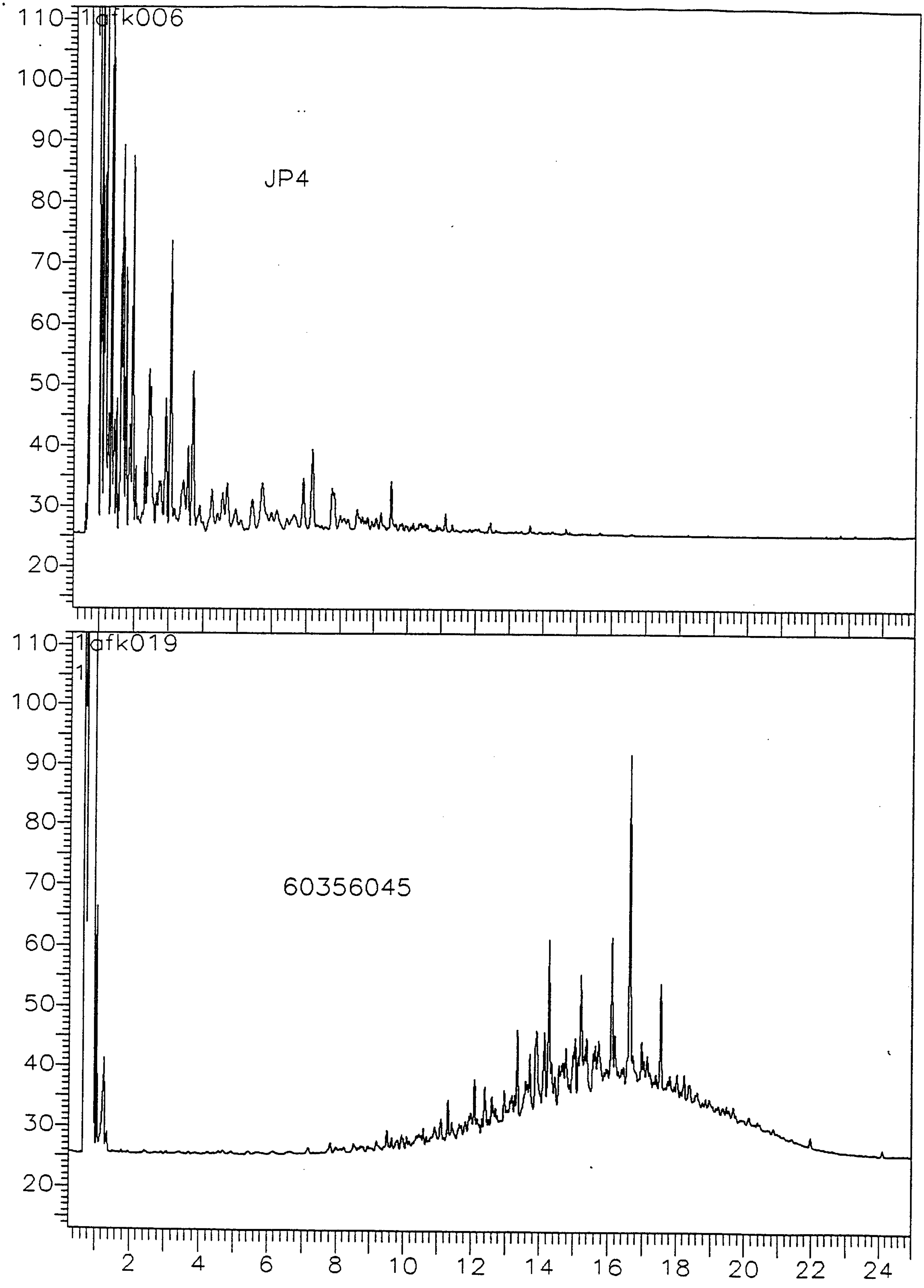
Sample Name : 60356045
FileName : c:\2700\ks101\1AFK019.raw
Method : TPHH.ins
Start Time : 0.00 min
Scale Factor: -1.0

End Time : 34.99 min
Plot Offset: 22 mV

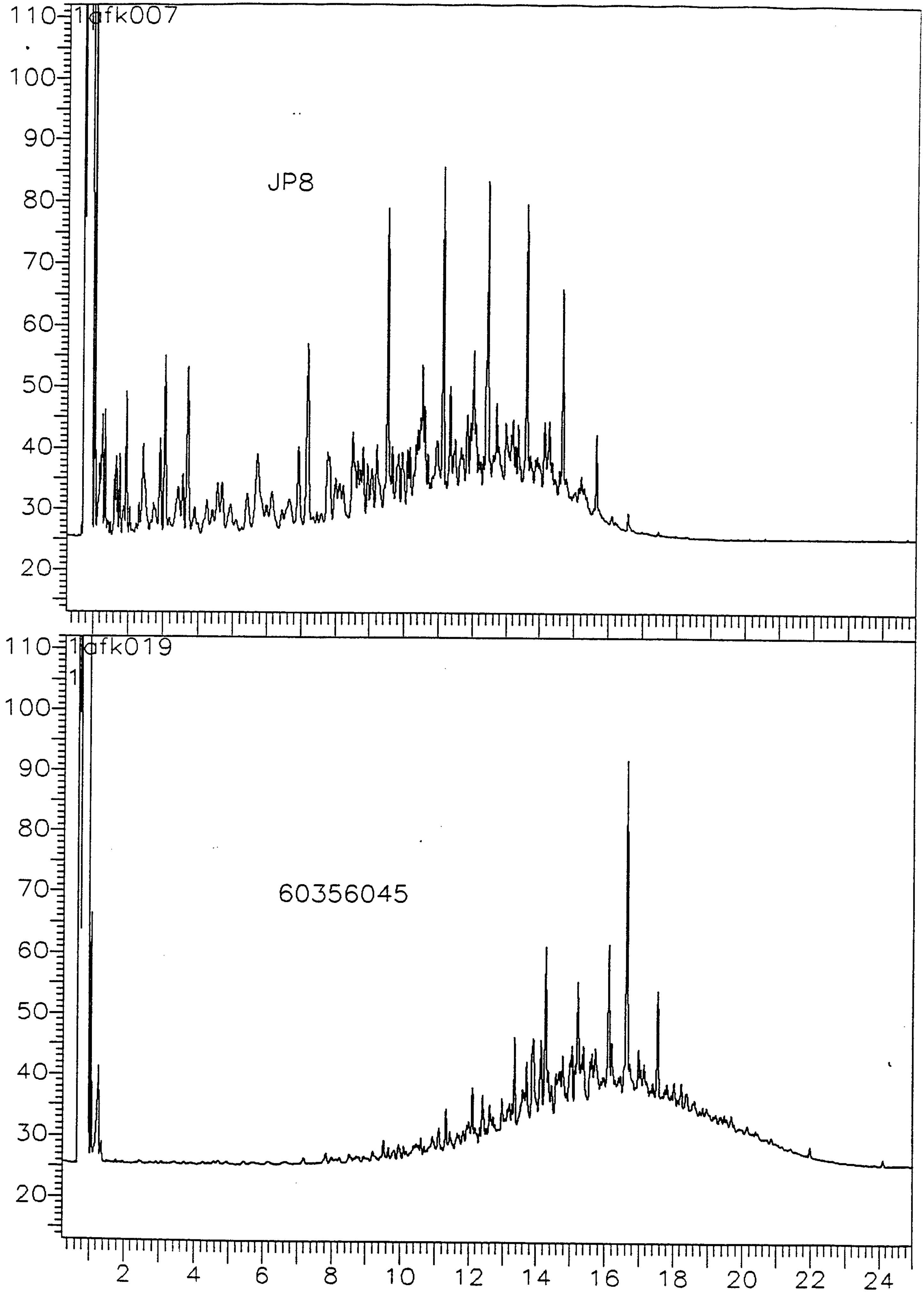
Sample #:
Date : 6/23/95 10:04
Time of Injection: 6/21/95 12:39
Low Point : 21.75 mV
Plot Scale: 70.0 mV

High Point : 91.75 mV

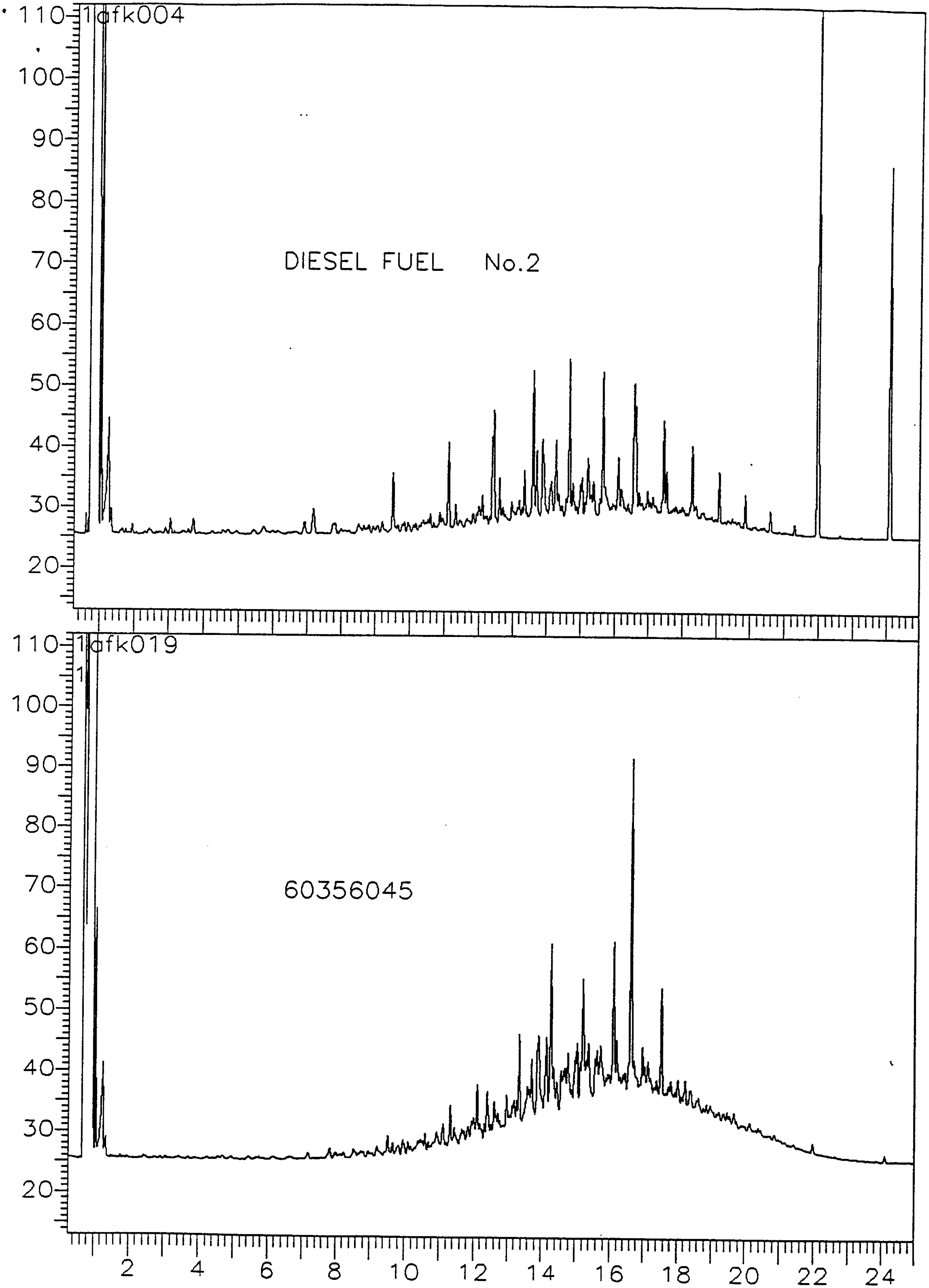




1afk006
JP4
1afk019
60356045



1afk007
JP8
1afk019
60356045


1afk004
DIESEL FUEL No.2
1afk019
60356045
110
100
90
80
70
60
50
40
30
20
2
4
6
8
10
12
14
16
18
20
22
24

J 123 - Bioventing -

583

Battelle
Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No. 001

CL 2447

Proj. No. G4468- G464201

Project Title: Bioventing Initiative Bioslurping

SAMPLERS: (Signature) [signature]

DATE	TIME	SAMPLE I.D.	BTEX	TPH	Sieve Analysis	bulk density	porosity	boiling pt dist	Container No.	Number of Containers	Remarks
0355955 ~~4/4~~	1350	J1 - 4.5 - 5.0'	X	X							Job 268.01
0355963 ~~4/4~~		J1 - 5.0 - 5.5'	X	X							Job 268.01
0355971 ~~4/5~~		J2 - 4.5 - 5.0'	X	X							Job 268.01
0355989 ~~4/5~~		J2 - 5.0' - 5.5'	X	X							Job 268.01
0355997 ~~4/5~~		J3 - 4.0 - 4.5'	X	X							Job 268.01
035600 ~~4/5~~		J3 - 4.5' - 5.0'	X	X							Job 268.01
60354011		JA4 5.0-5.5	X	X							Comment: fr
60354029		JA4 5.5-6.0	X	X							ship Fuel
60354037		JA4 7.0-7.5	X	X							
		JA4 4.5-6.0			X	X	X			2 JARS	SENT TO ENV.
		JA4 6.0-7.5			X	X	X			2 JARS	GEO TECHNOLOGY
60354045		JA4 - FUEL	X					X		1 vial	FUEL
		~~JA4~~	X					X			Comment: send Fuel sample back to OCSC region!!

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
[signature]	6/06/95	D. Rodz 83	D. Rodz 83	6/8/95 1600	FED EX
Relinquished by: (Signature)	**Date/Time**	**Received by: (Signature)**	**Relinquished by: (Signature)**	**Date/Time**	**Received by: (Signature)**
		Ray Herzog	6/9 @ 13:00		
Relinquished by: (Signature)	**Date/Time**	**Received for Laboratory by: (Signature)**	**Date/Time**	**Remarks**	
				Questions: Contact Al Pollack (614) 424-3753	

Page 1 of 1

Table C1. Depths to Fuel and Groundwater at Monitoring Wells PRW #3 and BAT WELL During the LNAPL Recovery Pump Tests

Date	Time	BAT WELL			PRW #3
		Depth to Fuel (ft)	Depth to Groundwater (ft)	Fuel Thickness (ft)	Depth to Groundwater (ft)
6/9/95	1930	6.21	6.28	0.07	7.26
6/10/95	0530	6.25	6.59	0.34	7.27
	0755	6.33	6.85	0.52	7.495
	0845	6.38	7.00	0.62	7.58
	1010	6.46	7.25	0.79	7.715
	1340	6.44	7.15	0.71	7.31
	1445	6.38	6.89	0.51	6.94
6/11/95	0700	6.27	6.63	0.36	7.32
	0930	6.38	7.03	0.65	7.58
	1145	6.49	7.39	0.90	7.78
	1512	6.38	6.94	0.56	7.08
	1820	6.14	6.17	0.03	6.65
6/12/95	0530	6.28	6.59	0.31	7.01
	0745	6.17	6.22	0.05	7.24
	0900	6.21	6.43	0.22	7.38
	1120	6.34	6.91	0.57	7.63
	1225	6.39	7.04	0.65	7.71
	1330	6.41	7.10	0.69	7.715
	1515	6.34	7.88	1.54	7.16
	2122	6.02	6.04	0.02	7.05
6/13/95	0800	6.03	6.28	0.25	
	0948	6.19	6.59	0.40	
	1200	6.325	7.285	0.96	
	1945	6.11	6.17	0.06	
	2043	6.05	6.10	0.05	

Table C1. Depths to Fuel and Groundwater at Monitoring Wells PRW #3 and BAT WELL During the LNAPL Recovery Pump Tests (continued)

Date	Time	BAT WELL			PRW #3
		Depth to Fuel (ft)	Depth to Groundwater (ft)	Fuel Thickness (ft)	Depth to Groundwater (ft)
6/14/95	0740	6.1	6.29	0.19	
	0923	6.13	6.43	0.30	
	1010	6.15	6.507	0.36	
	1100	6.21	6.77	0.56	
	1230	6.26	7.34	1.08	
	1341	6.32	7.64	1.32	
	1545	6.335	7.68	1.35	
	1900	6.25	6.75	0.50	
	1945	6.165	6.44	0.28	

APPENDIX D

SYSTEM CHECKLIST

Checklist for System Shakedown

Site: Johnston Atoll T-49

Date: 05 Jun 95

Operator's Initials: ______

Equipment	Check if Okay	Comments
Liquid Ring Pump	✓	Wired directly to 120V outlet. Bypassed controller
Aqueous Effluent Transfer Pump		
Oil/Water Separator	✓	
Vapor Flowmeter	✓	
Fuel Flowmeter	✓	
Water Flowmeter	✓	
Emergency Shut off Float Switch		Disconnected
Effluent Transfer Tank		"
Analytical Field Instrumentation		
GasTector™ O_2/CO_2 Analyzer	✓	
TraceTector™ Hydrocarbon Analyzer	✓	
Oil/Water Interface Probe	✓	
Magnehelic Boards	✓	
Thermocouple Thermometer	✓	

APPENDIX E

DATA SHEETS FROM THE SHORT-TERM PILOT TEST

Baildown Test Record Sheet

Site: JA-4 / JOHNSTON ATOLL

Well Identification: PRW-13

Well Diameter (OD/ID): 2" SCH 40 PVC

Date at Start of Test: 02 JUN 95

Sampler's Initials: JK

Time at Start of Test: 1426

Well stick up = 1.55'

Initial Readings

READINGS FROM TOP OF CASING

Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)	Total Volume Bailed (L
8.01'	6.41	1.6'	3.5

Test Data

Sample Collection Time	Depth to Groundwater (ft)	Depth to LNAPL (ft)	LNAPL Thickness (ft)
1426 / time 0	7.02	6.60	0.42'
1436 / 10 min.	7.64	6.485	1.155'
1440 / 14 min.	7.25	6.47	0.78'
1550 / 74 min.	7.935	6.43	1.505'
03 JUN 95 0925 (High Tide)	6.64'	6.39	0.25'

FUEL AND WATER RECOVERY DATA

Site: JA-4/Johnston Atoll

Start Date: 05 JUN 95

Test Type: Skimmer

Operators: Headington/Woolfe

Date/Time	Time	LNAPL Recovery	Groundwater Recovery
05 JUN 95/1617	0	0	0
1634		1175 cc	—
1718		675 cc	
1842		2000 cc	
06 JUN 95/ 0815		7.1 GAL	45 GAL
/1540		6.3 GAL ~~13.4~~ GAL	36 GAL
/2000		5.8 GAL	38 GAL
07 JUN 95/ 0730		13.4 GAL	
0800		1.9 GAL	
pump down for		2 HRS	(1040 – 1240 HRS)
07 JUN 95/1600		15.2 GAL	149 GAL
07 JUN 95/1600	Skimmer clean up	7.1 GAL	—
Total Fuel/water	46 HRS	56.8 GAL	268.2 GAL

1.23 GAL/HR

5.8 GPH

0.09 gpm

FUEL AND WATER RECOVERY DATA

Site: JA-4 / Johnston Atoll

Start Date: 08 JUN 95

Test Type: SLURPER

Operators: Heudington / Woolfe

PAGE 1 of 2

Date/Time	Time	LNAPL Recovery	Groundwater Recovery
08 JUN 95/ 0820	0	—	—
1000	100 min	26.1 GAL	1.38 GAL/min
1122	182 min	18.8 GAL	
1315	295 min	20.6 GAL	220 GALLONS
1439	379 min	Shut off for	58 min.
1642	444 min	14.4 GAL	~~NA / [illegible]/min~~ 147.8
1900	582 min	—	170.2 GAL
2052	694 min	8.7 GAL	133.9 GAL
2316	838 min	9.6 GAL	116.1 GAL
09 JUN 95/ 0600	1242 min	13.6 GAL	
1240	1642 min	15.1 GAL	
1930	2052 min	4.2 GAL	1054.9 GAL
10 JUN 95 / 0530	2652 min	10.6 GAL	621 GAL
0850	2852 min	NA	199 GAL
1015	2937 min	RATE 4 GAL/HR	RATE = 0.76 GPM
1031	2953 min	NA	81 GAL
1350	3152 min	13.1 GAL	155 GAL
1400	3162 min	RATE 0.12 GPH	RATE = 1.06 GPM
52.5 HOURS totals		154.8 GALLONS	total = 2898.9 GALLONS
		AVG. = 2.95 GPH	AVG. = 0.92 GPM

Note: Fuel Storage Tank has approx 20 gallons OF WATER in bottom, if subtracted the total fuel to date = ~~129.8~~ 134.8 GALLONS

FUEL AND WATER RECOVERY DATA

Site: JA-4/Johnston Atoll Start Date: 08 JUN 95

Test Type: SLURPER Operators: Headington/Woolfe

PAGE 2 OF 2

Date/Time	Time	LNAPL Recovery	Groundwater Recovery
10 JUN 95/2100	3582 min	3.3 GAL	442
11JUN95/0700	4182 min	9.1 GAL	583.4
1150	4472 min	8.3 GAL/RATE 3.1 GPH	306.6
1210	4492 min	—	RATE = 0.81 GPM
[75.3 HRS] 1235	4517 min	1.8 GAL	37 GAL
1505	4667 min	3.4 GAL	121.3 GAL
	total =	180.7 (-)	H_2O = 160.7 GALLON
	After cleaning	seperator add	3.3 Gallon to total
Slurping	total fuel =	164 GALLONS	collected

~~total fuel = 177 gal~~

FUEL AND WATER RECOVERY DATA

Site: JA-4 / Johnston

Start Date: 12 JUN 95

Test Type: 24 HR SKIMMER

Operators: Headington / Woolfe

Date/Time	Time	LNAPL Recovery	Groundwater Recovery
12 JUN — 13 JUN	22 HRS.	3.3 GAL	396 Gallons
			18 Gallons / Hour
			0.3 gpm

FUEL AND WATER RECOVERY DATA

Site: JA-4 / Johnston Atoll

Start Date: 13 JUN 95

Test Type: Drawdown

Operators: Headington

Date/Time	Time	LNAPL Recovery	Groundwater Recovery
13 JUN 95 / 0900	0 min		
13 JUN 95 / 2000	660 min	4.0 GALLONS	557 GALLONS
13 JUN 95 / 2230	810 min	0.25 GALLONS	260 GALLONS
System shut off at 2230 HRS. (Power outage)			
Restart system 14 JUN 95 / 0800 HRS			
14 JUN 95 / 0800	810 min	NA.	NA
14 JUN 95 / 0930	900 min	NA.	41 GALLONS
14 JUN 95 / 1100	990 min	NA.	73 GALLONS
14 JUN 95 / 2000	1530 min.*	5.3 GALLON	634 GALLONS
Totals —	25.5 HR	9.55 GALLONS	1565 GALLONS
	AVERAGE =	0.375 GPH —	1.02 GPM

* Note: Fuel collected on 14 JUN 95 was collected between the hours of 1000 – 2000 hours, didn't see any recovery for the first 2 hours of running on June 14. Also note that during high tide the system would shut down.

APPENDIX F

SOIL GAS PERMEABILITY TEST RESULTS

Record Sheet for Air Permeability Test

Site JA4 TANK 49	**Monitoring Point** A
Blower Type 3hp SLURPER	**Distance from Vent Well** 5.60'
Depth of Point G= 2.5' | R= 5.0'	**Recorded by** WOOHE

Time	G ~~MP1~~	R ~~MP2~~	MP3	Time	G ~~MP1~~	R ~~MP2~~	MP3
0	0.0"	0.0"		42 min	.70	.70	
1 min	.50	.50		45 min	-	-	
2 min	.50 ~~0.7~~	.50		48 min			
3 min	.50	.50		50 min	.66	.70	
4 min	.50	.50		60 min	.66	.66	
5 min	.50	.50		70 min	.65	.70	
6 min	.50	.50		80 min	.66	.66	
7 min	.50	.50		90 min	.66	.66	
8 min	.50	.50					
9 min	.50	.50					
10 min	.50	.50					
12 min	.45	.45					
14 min	.45	.45					
16 min	.70	.70					
18 min	.70	.75					
20 min	.75	.75					
22 min	.70	.70					
24 min	.70	.70					
26 min							
28 min							
30 min	.70	.70					
33 min							
36 min	.70	.70					
39 min							

Record Sheet for Air Permeability Test

Site JA4 TANK 49	Monitoring Point B
Blower Type 3hp. SLURPER	Distance from Vent Well 10'
Depth of Point G=2.5' | R=5.0'	Recorded by WOOLFE

Time	G ~~MP1~~	R ~~MP2~~	MP3	Time	MP1	MP2	MP3
0	0.0	0.0		42 min			
1 min	.0.1	.0.1		45 min	.03	.12	
2 min	.0.1	.0.1		48 min			
3 min	.0.7	.0.7		50 min	.03	.12	
4 min	~~.06~~ .05	.10		60 min	.035	.125	
5 min	.02	.08		70 min	.03	.125	
6 min	.02	.08		80 min	.025	.125	
7 min	.02	.08		90 min	.02	.13	
8 min	.01	.0.8					
9 min	.0.2	.09					
10 min	.02	.075					
12 min	.01	.07					
14 min	.015	.085					
16 min	.025	0.12					
18 min	.02	.13					
20 min	.025	.11					
22 min	.02	.12					
24 min	.025	.12					
26 min							
28 min							
30 min	.03	.12					
33 min							
36 min	.025	.12					
39 min							

Record Sheet for Air Permeability Test 08 JUN 95 Start 0820							
Site JA 4 Tank 49				Monitoring Point C			
Blower Type 3 HP SLURPER				Distance from Vent Well 20'			
Depth of Point G = 2.5' / R = 5.0'				Recorded by Headington			
Time	G ~~MP1~~	R ~~MP2~~	MP3	Time	G ~~MP1~~	R ~~MP2~~	MP3
0 -	0.0"	0.0"		42 min			
1 min	0.08	0.05"		45 min			
2 min	0.1"	0.06		48 min			
3 min	0.11	0.07		50 min	0.125	0.078"	
4 min	——	——		80 min	0.11	0.068	
5 min	——	——		90 min	0.11	0.065	
6 min	0.10	0.07					
7 min							
8 min							
9 min							
10 min							
12 min	0.08	0.07					
14 min	0.12"	0.09					
16 min							
18 min							
20 min							
22 min	0.13"	0.09"					
24 min							
26 min							
28 min							
30 min	0.125	0.08"					
33 min							
36 min							
39 min							

AIRPERM.RS (G462201-1001 DISK)

BATTELLE	RECORD SHEET FOR AIR PERMEABILITY TEST			DATE/TIME:
TYPE OF BLOWER:		SIZE OF BLOWER (HP):		SITE:
				RECORDED BY:
TIME FROM START-UP (MIN.)	PRESSURE (PSI)	FLOW (SCFM)	TEMP (°C)	COMMENTS
2 min	15" Hg	0.05	26°	Pump VAC
4 min				BAT well 0.65" H_2O
16 min	10" Hg	0.10" DP		BAT well 0.9" H_2O
21 min		~~0.1~~		extraction well > 20" H_2O
30 min	10" Hg	0.115" DP		6.21' DTF 7.76' DTW (34 min)
50 min	10" Hg	0.12 DP	30.0°C	extraction well VAC = 22" H_2O

7.76
6.21
1.55

APPENDIX G

IN SITU RESPIRATION TEST RESULTS

In Situ Respiration Test

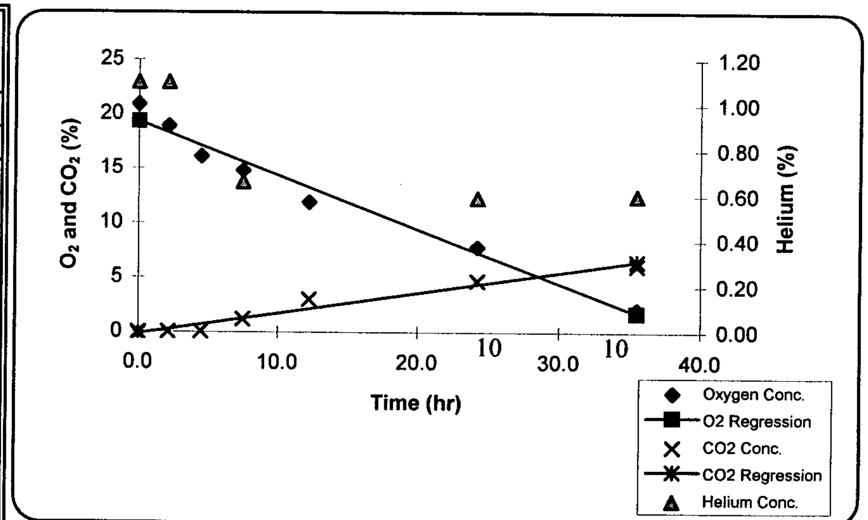
Date: 6/29/95

Site Name: JA4

Monitoring Point: A

Depth of M.P. (ft):

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
6/13/95 7:30	0.0	20.90	0.00	1.10
6/13/95 9:40	2.2	18.90	0.04	1.10
6/13/95 12:00	4.5	16.10	0.05	
6/13/95 15:00	7.5	14.80	1.20	0.66
6/13/95 19:45	12.2	11.90	3.00	
6/14/95 7:45	24.2	7.80	4.70	0.59
6/14/95 19:00	35.5	2.10	6.10	0.60



O_2 Utilization Rate

Ko 0.008 %/min
0.495 %/hr
11.889 %/day

Regression Lines	O_2	CO_2
Slope	-0.4954	0.1873
Intercept	19.3123	-0.1498
Determination Coef.	0.9737	0.9605
No. of Data Points.	7	7

In Situ Respiration Test

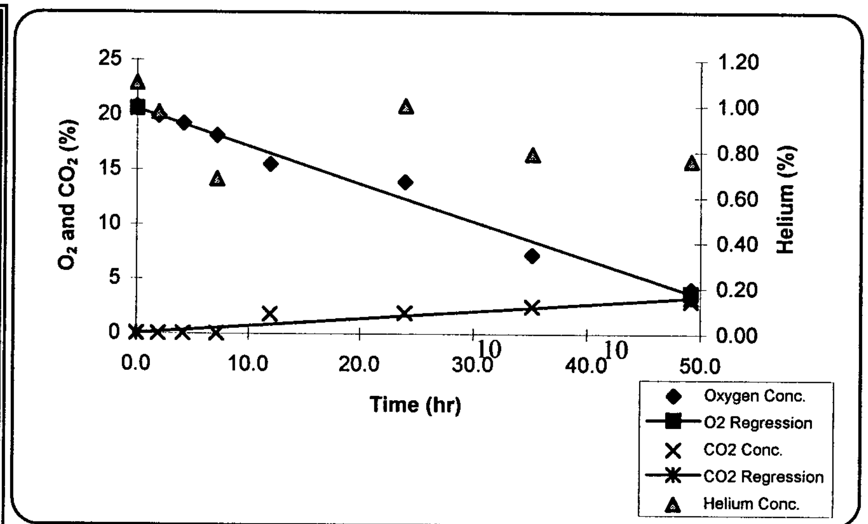
Date: 6/29/95

Site Name: JA4

Monitoring Point: C-Red

Depth of M.P. (ft):

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
6/13/95 7:50	0.0	20.80	0.00	1.10
6/13/95 9:48	2.0	19.90	0.03	0.97
6/13/95 12:00	4.2	19.20	0.04	
6/13/95 15:00	7.2	18.10	0.04	0.68
6/13/95 19:45	11.9	15.50	1.80	
6/14/95 7:50	24.0	13.90	1.90	1.00
6/14/95 19:00	35.2	7.20	2.50	0.79
6/15/95 9:00	49.2	4.10	3.00	0.76



O_2 Utilization Rate

Ko	0.006	%/min
	0.343	%/hr
	8.230	%/day

Regression Lines	O_2	CO_2
Slope	-0.3429	0.0666
Intercept	20.5619	0.0517
Determination Coef.	0.9800	0.8722
No. of Data Points.	8	8

In Situ Respiration Test

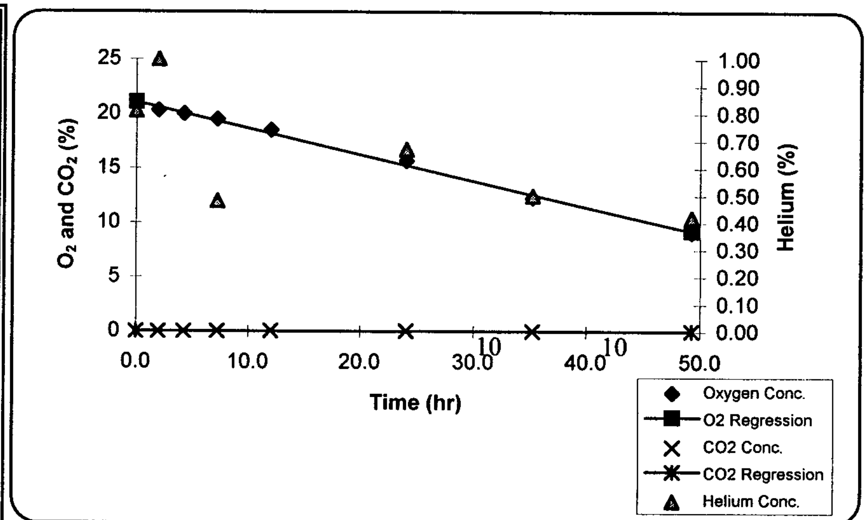
Date: 6/29/95

Site Name: JA4

Monitoring Point: C-Green

Depth of M.P. (ft):

Date/Time (mm/dd/yr hr:min)	Time (hr)	Oxygen (%)	Carbon Dioxide (%)	Helium (%)
6/13/95 7:45	0.0	20.80	0.00	0.81
6/13/95 9:45	2.0	20.30	0.00	1.00
6/13/95 12:00	4.3	20.00	0.00	
6/13/95 15:00	7.3	19.50	0.04	0.48
6/13/95 19:45	12.0	18.50	0.05	
6/14/95 7:50	24.1	15.70	0.05	0.67
6/14/95 19:00	35.3	12.30	0.05	0.50
6/15/95 9:00	49.3	9.10	0.05	0.42



O_2 Utilization Rate

Ko 0.004 %/min
0.241 %/hr
5.774 %/day

Regression Lines	O_2	CO_2
Slope	-0.2406	0.0010
Intercept	21.0570	0.0127
Determination Coef.	0.9956	0.5401
No. of Data Points.	8	8